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# U.S. ARMY

# TEST & EVALUATION COMMAND

USATECOM PROJECT NO. 4-4-114-01

**FINAL REPORT OF**

**PERFORMANCE TESTS**

**OF THE**

**CV-2B AIRPLANE**

JUNE 1965

HEADQUARTERS
U.S. ARMY AVIATION TEST ACTIVITY
EDWARDS AFB, CALIFORNIA

**U.S. ARMY AVIATION TEST ACTIVITY**

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# FINAL REPORT OF PERFORMANCE TESTS OF THE CV-2B AIRPLANE

**USATECOM PROJECT NO. 4-4-1141-01**

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TABLE OF CONTENTS

| | | Page |
|---|---|---|
| ABSTRACT | | v |
| SECTION 1. | GENERAL | 1 |
| | 1.1 References | 1 |
| | 1.2 Authority | 2 |
| | 1.3 Test Objectives | 2 |
| | 1.4 Responsibilities | 3 |
| | 1.5 Description of Materiel | 3 |
| | 1.6 Background | 4 |
| | 1.7 Findings | 4 |
| | 1.8 Conclusions | 4 |
| | 1.9 Recommendations | 6 |
| SECTION 2. | DETAILS OF TEST | 7 |
| | 2.0 Introduction | 7 |
| | 2.1 Stall Characteristics in the STOL Configuration | 8 |
| | 2.2 Takeoff Performance and Flying Qualities in the STOL Configuration | 16 |
| | 2.3 Sawtooth Climbs | 27 |
| | 2.4 Continuous Climbs | 29 |
| | 2.5 Level Flight | 31 |
| | 2.6 Landing Performance and Flying Qualities in the STOL Configuration | 35 |
| | 2.7 Airspeed Calibration | 42 |
| SECTION 3. | APPENDICES | I-1 |
| | I. Test Data | I-1 |
| | II. Data Analysis Methods | II-1 |
| | III. General Aircraft Information | III-1 |
| | IV. Distribution List | IV-1 |

## ABSTRACT

Engineering flight tests were conducted to evaluate the performance and flying qualities of the CV-2B airplane, with special emphasis on takeoff and landing performance in the short takeoff and landing (STOL) configuration. This test program was conducted by the U. S. Army Aviation Test Activity (USAAVNTA), Edwards Air Force Base, California.

Tests were conducted at test sites in Bakersfield, Edwards, Bishop, Stateline and Coyote Flats, California. The program consisted of 120 hours of flight testing and was accomplished during the period 25 August 1963 through 20 January 1964. An interim report was submitted to the Assistant Chief of Staff for Force Development, U. S. Army, 9 March 1964.

The test airplane (U. S. Army S/N 62-4175) was modified from a CV-2 to a CV-2B by the incorporation of the following major changes:

a. STOL operation capabilities were increased from 26,000 pounds to 28,500 pounds.

b. Reverse pitch propellers were installed.

The STOL performance data obtained during this test revealed that the Operator's Manual (TM-55-1510-206-10) does not adequately present STOL procedures or performance for all combinations of gross weight, altitude and C.G. position.

No significant difference exists between the cruise performance data obtained during this evaluation and that found in the Operator's Manual. The Operator's Manual, however, does not present any level flight data for the ferry gross weight of 31,300 pounds.

The stall characteristics information presented in the Operator's Manual for the STOL configuration is inadequate.


**CV-2B CARIBOU**

# SECTION 1 - GENERAL

## 1.1 REFERENCES

a. Message No. 8-1046, AMCPM-CA, Hq, U. S. Army Materiel Command (USAMC), 9 August 1963, subject: "CV-2B Performance Tests in the STOL Configuration and Tests to Update the Appropriate Manuals."

b. ATA-TR-63-4, "Takeoff and Landing Capabilities of the Caribou CV-2B Aircraft on Unprepared Surfaces," U. S. Army Aviation Test Activity (USAAVNTA), September 1963.

c. Report, AFFTC-TR-60-41, "YAC-1DH Category II Performance and Stability Tests," U. S. Air Force Flight Test Center (AFFTC), November 1960.

d. Report, AFFTC-TR-60-41, "Appendix III, YAC-1DH Category II Performance and Stability Tests," AFFTC, November 1960.

e. Technical Manual TM-55-1510-206-10, "Operator's Manual AC-1 Aircraft," Department of the Army, June 1962 (Changes No. 1 and 2 incorporated).

f. Message STEAV-E 9-3-19, Hq, USAAVNTA, 9 March 1964, subject: "Data for Use in Updating the Standard Aircraft Characteristics Charts for the CV-2B."

g. Military Specification MIL-F-8785 (ASG) Amendment 4, "Flying Qualities of Piloted Aircraft," 17 April 1959.

h. PWA.OI.85, "Specific Operating Instructions Twin Wasp D5," Pratt and Whitney Aircraft, 1 October 1955.

i. Report AFFTC-TR-6273, "Flight Test Engineering Handbook," U. S. AFFTC, June 1964.

j. Report AFFTC-TN-R-12 "Standardization of Takeoff Performance Measurements for Airplanes," U. S. AFFTC, 1948.

k. Brown Book of Standard Aircraft Characteristics, U. S. Air Force, August 1963.

l. PWA.OI.60, "The Use of Operating Curves," Pratt and Whitney Aircraft, November 1945.

m. Civil Aeronautics Manual 4B, "Airplane Airworthiness; Transport Categories," Federal Aviation Agency, September 1962.

n. Elements of Practical Aerodynamics, Bradley Jones. John Wiley and Sons, Inc., New York, 1957.

o. Airplane Performance Stability and Control, Courtland D. Perkins and Robert E. Hage. John Wiley and Sons, Inc., New York, 1957

p. Principles of Aerodynamics, James H. Dwinnell. McGraw-Hill Book Company, Inc., New York, 1949

q. Pilot Techniques for Stability and Control Testing, Lt. Colonel C.B. Doyle, USMC. Test Pilot Training Division, Naval Air Test Center, 15 March 1955.

## 1.2 AUTHORITY

Message No. 8-1046, AMCPM-CA, Hq, U.S. Army Materiel Command (USAMC), 9 August 1963, subject: "Test Directive, CV-2B Performance Tests in the Short Takeoff and Landing (STOL) Configuration and Tests to Update the Appropriate Manuals."

## 1.3 TEST OBJECTIVES

The objectives of this flight test evaluation were to validate and to update data for the CV-2B airplane's performance and flying qualities for entry into the appropriate manuals. The areas of particular interest were:

a. Takeoff and landing performance while operating in the STOL configuration.

b. Conventional performance up to the increased ferry gross weight limit (31,300 pounds).

c. STOL landing performance while using reverse thrust.

It was evident from previous CV-2 reports (References 1.1.b, 1.1.c and 1.1.d) that the STOL flying qualities significantly affect the ability of the pilot to obtain maximum takeoff and landing performance. A qualitative stability and control evaluation was, therefore, conducted in conjunction with the STOL performance evaluation, with particular emphasis on the following items:

a. Effects of altitude, gross weight, and center of gravity (C.G.) on stability and control characteristics while operating in the STOL configuration.

b. Ground handling qualities with and without the use of the reverse thrust propeller mode.

c. Suitability of primary flight controls and cockpit configuration for STOL operation.

## 1.4 RESPONSIBILITIES

The U. S. Army Aviation Test Activity (USAAVNTA) was designated as Executive Test Agency for this flight test evaluation and as responsible for test planning, test execution, and test reporting.

## 1.5 DESCRIPTION OF MATERIEL

The CV-2B "Caribou" is an all-metal, high-wing, twin-engine, tricycle-gear, medium troop/cargo transport with short takeoff and landing capability. The airplane is designated for operations from unprepared surfaces. Power is supplied by two R-2000-7M2 twin wasp engines equipped with Hamilton Standard, full-feathering, constant-speed propellers. Each engine is rated at 1450 brake horsepower (BHP) for takeoff at sea level. The tricycle landing gear, hydraulically actuated, is fully retractable. Electrically-operated cargo and ramp doors in the rear of the airplane are used for loading and unloading troops and cargo. High lift devices incorporated in the airplane consist of hydraulically-actuated, double-slotted, full-span flaps, wing fences and dropped-wing leading edges. Normal flight crew consists of a pilot, copilot and crew chief. Seating for 34 fully equipped troops is provided in the main cabin. Fuel is carried in rubberized wing cells that have a capacity of 828 gallons. The maximum gross weight of the airplane (except for ferry) is 28,500 pounds. (See Reference 1.1.e for additional details).

One CV-2B airplane, Serial Number 62-4175, was used for this evaluation. The basic configuration of the airplane was standard except for the installation of reverse thrust (propeller) assemblies. During testing, the external configuration was standard except for a 4-foot swivel-head airspeed boom mounted on the nose of the airplane, an outside air temperature (OAT) probe mounted on the lower right side of the nose, and strain gages attached to the landing gear struts. The internal configuration was standard except for special cockpit instrumentation and a work table, seat, photo panel and oscillograph installed in the main cabin for use by the flight test engineer. Ballast boxes located in the main cabin were filled with varying amounts of lead to obtain the required weight and C.G. for each test. See Section 3, Appendix III, for a listing and photographs of installed test instrumentation.

## 1.6 BACKGROUND

The CV-2 airplane has been in use by the U. S. Army since 1959. The flying and ground handling qualities of the airplane have been evaluated and reported upon by the contractor and by various U. S. Government agencies.

The USAAVNTA was directed by the USAMC on 4 August 1963 to conduct performance tests to validate and update performance data for entry into the appropriate manuals (Reference 1.1.a).

Data for use in updating the standard aircraft characteristics charts for the CV-2B were transmitted by USAAVNTA on 9 March 1964 to the Assistant Chief of Staff for Force Development, Department of the Army (DA), Washington, D.C. (Reference 1.1.f).

## 1.7 FINDINGS

See Section 2 for a full discussion of test findings.

## 1.8 CONCLUSIONS

It is concluded that the cockpit configuration, ground handling qualities, STOL configuration flying qualities and STOL takeoff and landing characteristics of the CV-2B are suitable for use except as stated in this report.

### 1.8.1 DEFICIENCY

Pitch-up at the stall in the STOL takeoff configuration was present when the C.G. was in the aft position (Paragraph 2.1.4.2.2).

### 1.8.2 SHORTCOMINGS

Correction of the following shortcomings is desirable:

a. Control system friction forces are not compatible with static stability characteristics (Paragraphs 2.1.4.2.1 and 2.6.4.5).

b. Lateral control effectiveness is too low near the stalling speed in the STOL takeoff configuration (Paragraph 2.1.4.1).

c. Longitudinal control force gradients are only slightly positive near the stalling speed in the STOL takeoff configuration (Paragraph 2.1.4.2).

d. Longitudinal control power available to effect stall recovery is limited with the C.G. in the aft position in the STOL takeoff configuration (Paragraph 2.1.4.2.3).

e. Both primary and secondary artificial stall warnings occur too soon in the STOL takeoff configuration (Paragraphs 2.1.4.4 and 2.2.4.5.5).

f. Stall characteristics information presented in the Operator's Manual (Reference 1.1.e) is inadequate (Paragraph 2.1.4.1).

g. Location of the nosewheel steering control requires a transfer of primary control effort during STOL takeoffs (Paragraph 2.2.4.5.3).

h. Longitudinal control forces are too low during takeoff rotation at aft C.G. positions (Paragraph 2.2.4.3).

i. Lateral control effectiveness is too low during the STOL climb sequence (Paragraph 2.2.4.5).

j. Low longitudinal control force gradients detract from pilot "feel" during the STOL climb (Paragraph 2.2.4.5.5).

k. Excessive nose-down pitch trim change is produced as a result of flap retraction in the STOL climb sequence (Paragraph 2.2.4.5.6).

l. Operator's Manual (Reference 1.1.e) does not present the optimum climb schedule for 22,000 and 31,300 pounds (Paragraph 2.3.4).

m. No single-engine climb or level-flight capability is possible while operating at normal rated power at the ferry gross weight of 31,300 pounds (Paragraphs 2.4.4 and 2.5.4).

n. Operator's Manual (Reference 1.1.e) does not present any level-flight data with the cargo and ramp doors open to various positions (Paragraph 2.5.4).

o. Effects and methods of obtaining airspeed stabilization during a STOL approach are not emphasized sufficiently in the Operator's Manual (Reference 1.1.e) (Paragraph 2.6.4.4).

p. Excessive adverse yaw-roll coupling exists with the flaps deflected (Paragraph 2.6.4.5).

q. Excessive lateral-directional trimming is required as a result of deflecting flaps to 40 degrees (Paragraph 2.6.4.5).

r. Sensitive airspeed indicators with increments of 1-knot intervals should be installed in the CV-2B airplane (Paragraph 2.6.4.5).

s. "Safe-Flight" indicator installed in the test airplane is not satisfactory as a primary reference for STOL approaches (Paragraph 2.6.4.5).

t. Flying qualities in the STOL landing configuration are generally unsatisfactory and do not enhance the pilot's ability to obtain maximum performance (Paragraphs 2.1.4.1, 2.6.4.5 and 2.1.4.3.2).

## 1.9 RECOMMENDATIONS

a. Studies should be initiated to eliminate the flying qualities deficiency and shortcomings outlined in Paragraphs 1.8.1 and 1.8.2.

b. The information contained in this report should be incorporated into the CV-2B Operator's Manual at the earliest possible date.

# SECTION 2 - DETAILS and RESULTS of SUB-TESTS

## 2.0 INTRODUCTION

The performance and flying qualities evaluation of the CV-2B airplane in the STOL and cruise configurations was conducted by USAAVNTA during the period 25 August 1963 through 30 January 1964. Sixty-one test flights were flown for a total of 120 productive test hours.

The performance tests were conducted at conditions stated in Table 1, unless otherwise specified:

TABLE 1. PERFORMANCE TEST CONDITIONS

| Gross Weight lb | Center of Gravity % MAC |
|---|---|
| 22,000 | Mid (26.0) |
| 26,000 | Fwd* (29.5) |
| 26,000 | Mid (34.15) |
| 26,000 | Aft* (39.0) |
| 27,000 | Mid (34.5) |
| 28,500 | Fwd* (31.0) |
| 28,500 | Mid (35.0) |
| 28,500 | Aft* (39.0) |
| 31,300 | Mid** (35.0) |

* Takeoff and landing tests only

** Climb and level flight tests only

All tests were conducted in non-turbulent atmospheric conditions to obtain accurate data. All data were obtained from sensitive instrumentation and hand-recorded or recorded on photo panel film. Structural gear loads were recorded by an oscillograph. Thirteen performance parameters were recorded by the photo panel and seven structural gear loads were recorded by an oscillograph. The standard pilot's and copilot's airspeed indicators were replaced with sensitive indicators. The complete instrumentation installation weighed approximately 300 pounds.

The design gross weight of the CV-2B is 26,000 pounds and the maximum gross weight is 28,500 pounds. The CV-2B also has an allowable ferry gross weight which is 31,300 pounds. The allowable C.G. travel is a function of gross weight (See Section 3, Appendix II).

A complete control system rigging check was made in accordance with the manufacturer's rigging specifications and tolerances. No control system components were replaced or adjusted throughout the test program.

The scope of the flying qualities evaluation was directly related to the requirements of the performance evaluation. Flying qualities and ground handling characteristics of the CV-2B were evaluated only to the extent necessary to complete successfully the performance tests.

## 2.1 STALL CHARACTERISTICS IN THE STOL CONFIGURATION

### 2.1.1 OBJECTIVE

The objectives of these tests were to evaluate the stall characteristics of the CV-2B airplane and to determine accurately the minimum safe flying speeds in STOL configurations.

### 2.1.2 METHOD

Stall tests were conducted at gross weights ranging from 24,000 pounds to 28,500 pounds. Center-of-gravity (C.G.) positions ranged from the forward to the aft limits for each representative gross weight. Altitude during the stalls ranged from 5000 feet to 8000 feet pressure altitude ($H_p$). All stalls were executed in either the takeoff (T/O) configuration or the landing (L) configuration. Takeoff and landing configuration details were as shown in Tables 2 and 3:

| [illegible] | | | |
|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | 30 | Down | [illegible] |
| 26,000 | 30 | Down | MPA |
| 28,500 | 25 | Down | MPA |

* Maximum power available (MPA) was used in all takeoff configuration stalls since takeoff power was not available at the altitudes required for the stall evaluation.

TABLE 3. STOL LANDING CONFIGURATION FOR STALL TESTS

| Gross Weight lb | Flaps deg | Landing Gear | Power |
|---|---|---|---|
| All weights | 40 | Down | Zero thrust* |

*Zero thrust determined from thrust indicators.

All stalls were initiated from trim airspeeds ranging from 60 to 65 knots indicated airspeed (KIAS) depending upon the configuration being evaluated. Approach to the stall was executed by decreasing airspeed at a rate of 1/2 to 1 knot per second to minimize dynamic effects. Airspeed, altitude and qualitative pilot comments were recorded during each stall.

### 2.1.3 RESULTS

Test results are presented in Table 4, Paragraph 2.1.4.4.

### 2.1.4 ANALYSIS

#### 2.1.4.1 General

In order to obtain maximum STOL performance in the CV-2B, it was necessary to operate the airplane near the stalling speed during the landing and takeoff sequence. It was, therefore, necessary to investigate the stall characteristics of the airplane prior to conducting maximum performance STOL testing to insure that airplane flying qualities near the stalling speed were compatible with operation of the airplane in this flight regime.

Handling characteristics of the CV-2B deteriorated as the stall was approached. Lateral-directional control power was low at the initiation of the approach to the stall and progressively deteriorated as airspeed decreased so that large control inputs were required to maintain steady-heading and wings-level flight attitude. Random rolling, predominantly to the right, could not be corrected with rudder inputs due to the positive to neutral dihedral effect characteristics. Rolling was, therefore, corrected with large lateral control inputs. These control inputs were tiring to the pilot due to lateral frictional forces and the lateral force gradient. An increase in lateral control effectiveness and a reduction in lateral force gradients in the STOL speed range are desirable.

Airplane yawing to the left was observed as the stall was approached so that just prior to the stall three-quarters to full-right rudder was required to maintain constant-heading flight. Rudder forces at full deflection were high but were within pilot capability for the duration of the stall sequence.

Longitudinal control power was adequate as the approach to the stall was commenced but deteriorated with decreasing airspeed. Large longitudinal control inputs were required to obtain desired attitudes as airspeed decreased to within 10 knots of the stall. No difficulty was experienced in maintaining longitudinal control of the airplane.

Airplane stall characteristics information contained in the Operator's Manual (Reference 1.1.e) was not adequate for the scope of this evaluation since the effect of C.G. position and varying power levels on stall characteristics was not presented. It was, therefore, necessary to determine the effects of power on stalling speeds and on flying qualities near the stall.

The airspeed system in the test airplane was not calibrated when the airplane was near a stalled condition in the STOL configuration. Quantitative stalling speed data obtained in this evaluation are presented in terms of indicated airspeed.

In accordance with the requirement of Military Specification MIL-F-8785(ASG), Paragraph 3.6.2 (Reference 1.1.g), the airplane was considered to be stalled when sudden and uncontrollable pitching and/or rolling was obtained or when minimum usable flying speed was obtained as a result of longitudinal control power limits.

2.1.4.2 Takeoff Configuration Stalls

2.1.4.2.1 Approach to Stall

The approach to the stall, at all weights and C.G. positions tested, was initiated from a trim airspeed of 60 KIAS. Trim, once set, was not changed throughout the stall sequence.

Longitudinal static stability varied significantly with C.G. position. Longitudinal control force gradient was positive with the C.G. in the forward position and was slightly positive to neutral with the C.G. in the aft position. At all C.G. positions, longitudinal control force gradients decreased as the stall was approached. This characteristic coupled with the longitudinal friction forces tended to degrade longitudinal control "feel." Correction of this shortcoming to provide improved stick-free stability at all C.G. positions within the approved flight envelope is desirable.

2.1.4.2.2 The Stall

At all weights and C.G. positions tested, the stall was characterized by uncontrollable rolling and pitching. Airplane pitch attitude at the stall was 20 to 25 degrees nose high.

With the C.G. in the forward position, the stall occurred at a control position between one-half and three-quarters aft of the neutral position. The stall was defined by a roll to the right and a small nose-down pitch. Left lateral control was not effective in returning the airplane to wings-level flight. The rolling characteristic associated with the stall is not considered desirable. Lateral control effectiveness should be improved in the CV-2B so that rolling action, once obtained, can be quickly and precisely terminated by an application of lateral control. Longitudinal control was weakly effective throughout the stall and longitudinal control force gradient at the stall was slightly positive so that precise longitudinal control inputs were difficult to execute. Sink rate obtained during the stall was approximately 500 feet per minute (FPM).

With the C.G. in the mid position, stall characteristics were essentially unchanged from those obtained with the C.G. in the forward position except that the stall occurred at a control position between one-quarter and one-half aft of the neutral position and no visible longitudinal pitching was observed.

With the C.G. in the aft position, longitudinal characteristics at the stall varied considerably from thoseobtained with the C.G. in the forward and mid positions. Lateral and directional characteristics remained essentially unchanged Approximately 5 knots above the stall, a low-amplitude longitudinal oscillation with a period of approximately 3 seconds was obtained. The oscillation was accompanied by a high frequency airframe buffet. Longitudinal control force gradients at this speed were neutral. Further reduction in airspeed then produced the stall which was characterized by a rapid roll to the right accompanied by a nose-up pitching motion. During the pitch-up the airspeed decreased 3 knots in 1 second below that which was indicated at the moment of stall. Immediate corrective action was necessary to preclude entering a dangerous attitude. The pitch-up obtained in this stall was unsatisfactory, particularly when coupled with low longitudinal control power. A warning note should be added to the Operator's Manual (Reference 1.1.e) to describe the stall characteristics in this configuration. The sink rate at the stall was approximately 500 to 700 fpm.

2.1.4.2.3 Recovery from Stall

At all weights and C.G. positions tested, recovery from the stall was obtained by an immediate application of forward longitudinal control. Airplane response to longitudinal control application was satisfactory at the forward C.G. position and was unsatisfactory at the aft C.G. position. Response at the C.G. position was at such a rate that a period of 3 to 5 seconds was required to pitch the airplane nose down through a level flight attitude with the control yoke positioned near the forward stop. Improved longitudinal response at the aft C.G. is desirable.

Longitudinal control, once positioned at the recovery deflection, was held until the airplane had pitched to a nose-down attitude of approximately 20 degrees. As airspeed increased through 60 KIAS, sufficient lateral control power was obtained so that the bank angle could be corrected. Recovery to level flight was initiated at 65-70 KIAS by application of aft longitudinal control. No secondary stall tendencies were observed when recovering in this speed range.

### 2.1.4.3 <u>Landing Configuration Stalls</u>

#### 2.1.4.3.1 Approach to the Stall

The approach to the stall at all weights and C.G. positions tested was initiated from a trim airspeed of 65 KIAS. Trim, once set, was not changed throughout the stall sequence.

The handling characteristics of the CV-2B during the approach to the stall in the STOL landing configuration were similar to those obtained in the STOL takeoff configuration. Lateral-directional control power was low at the trim airspeed and deteriorated further as airspeed was reduced. Longitudinal control power was adequate at the trim airspeed but deteriorated with decreasing airspeed.

In the landing configuration, airplane excursions in roll and yaw were not as pronounced as those obtained in the takeoff configuration. The longitudinal control force gradient was slightly positive at the initiation of the approach to the stall and deteriorated with decreasing airspeed.

No natural aerodynamic buffet was obtained with the C.G. in the mid and forward position; however, with the C.G. in the aft position, a low-amplitude longitudinal oscillation accompanied by weak random elevator buffet was obtained as airspeed decreased to within 2 to 3 knots of the stall. No difficulty was experienced in controlling this oscillation.

#### 2.1.4.3.2 The Stall

The longitudinal control power available in the STOL landing configuration was of sufficient magnitude to produce an aerodynamic stall with the C.G. in the mid and aft positions. With the C.G. in the forward position, however, the CV-2B exhibited longitudinal control limited stall characteristics. Yoke position at the stall ranged from one-quarter aft of the neutral position with the C.G. in the aft position to full aft with the C.G. in the forward position.

With the C.G. in the mid and aft positions, the stall was defined by a rolling to the right, similar to that obtained in the takeoff configuration, accompanied by slight nose-down pitching motion. Bank angles of approximately 20 degrees were obtained prior to commencing stall recovery procedures. Lateral control effectiveness was low and required large lateral control deflections. Correction of this shortcoming is desirable. With the C.G. in the forward position, the stall was characterized by random low-amplitude pitching motions and random rolling motions in both directions.

Small directional inputs were required to maintain steady-heading flight throughout the stall sequence.

As in the STOL takeoff configuration, the slightly positive to neutral longitudinal force gradient obtained at the stall was unsatisfactory because pilot "feel" for control position and attitude change was degraded.

2.1.4.3.3 Recovery from the Stall

As in the STOL takeoff configuration, recovery from the stall was obtained by a forward application of longitudinal control to such a position that a nose-down pitch to an attitude of approximately 20 degrees nosedown was obtained.

2.1.4.4 Quantitative Test Data

In addition to the qualitative stall evaluation presented in the foregoing paragraphs, the following quantitative data were obtained:

TABLE 4. SUMMARY OF QUANTITATIVE STALL TEST DATA

| (1) Configuration | (2) Gross Weight lb | (3) $V_{stall}$ KIAS | (4) $V_{prim}$ Shaker KIAS | (5) $V_{sec}$ Shaker KIAS | (6) $\frac{V_{prim\ warn}}{V_s}$ | (7) $\frac{V_{sec\ warn}}{V_s}$ |
|---|---|---|---|---|---|---|
| T/O | 24,000 | 45 | 53 | 49 | 1.18 | 1.09 |
| T/O | 26,000 | 47 | 55 | 52 | 1.17 | 1.11 |
| T/O | 28,500 | 49 | 60 | 58 | 1.22 | 1.18 |
| L | 24,000 | 56 | 59 | None | 1.05 | -- |
| L | 26,000 | 57 | 59 | None | 1.04 | -- |
| L | 28,500 | 58 | 61 | None | 1.05 | -- |

Examination of Table 4 shows that an increase in indicated stalling airspeed occurred in both STOL configurations as gross weight was increased. There was also a corresponding variation in the speeds at which artificial stall warning was obtained. Column 6 lists the stall warning speed as a ratio to the indicated stalling speed for the particular configuration and weight. Due to the design of the stall warning system, secondary stall warning was not activated in the landing configuration. Primary stall warning ranged from 1.17 $V_s$ to 1.22 $V_s$ in the takeoff configuration and from 1.04 $V_s$ to 1.05 $V_s$ in the landing configuration. Secondary stall warning ranged from 1.09 $V_s$ to 1.18 $V_s$ in the takeoff configuration.

The artificial stall warning margins obtained were significant since natural aerodynamic buffeting was either not obtained in the evaluation stalls or, if obtained, was so weak that it could not be detected with the artificial stall warning system in operation.

Both the primary and secondary artificial stall warning stick shakers were very effective in warning the pilot of the impending stall. In the takeoff configuration, however, primary stall warning occurred at higher indicated airspeeds than required (1.17 $V_s$ to 1.22 $V_s$). As a result, in the majority of STOL takeoffs performed, where maximum performance and flying qualities of the airplane were satisfactory, the climb sequence through 50 feet was performed with the primary stick shaker activated. This was undesirable because it was disconcerting to the pilot. Additionally, the secondary stall warning shaker, when engaged at 1.09 $V_s$ to 1.18 $V_s$, activated the control column in a low-frequency, large-amplitude vibration. The amplitude and frequency of the vibration were very disconcerting particularly when obtained between airplane lift-off and the climb through 50 feet. The engagement of the stick shaker was sudden and the resulting control column vibration was severe enough to mask control "feel" at a critical point in the takeoff maneuver.

An additional shortcoming of the stall warning system was observed as a result of the stall warning margin. STOL takeoffs executed in light turbulence were often accompanied by momentary stick shaker activation caused by gust action on the airplane. This was also disconcerting to the pilot as stick shaker activation was intermittent and could not be quickly interpreted.

It is desirable that stall warning margin in the CV-2B be decreased in the STOL configuration so that the maximum performance STOL takeoff sequence from lift-off through 50 feet can be accomplished at the speeds recommended in this report without stick shaker action.

In the landing configuration, primary stick shaker speed margin of 1.04 $V_s$ to 1.05 $V_s$ was compatible with the maximum performance approach speeds recommended in this report and was satisfactory at all weights and C.G. locations tested. Use of the approach airspeeds recommended in this report resulted in no stick shaker action until the landing flare was commenced. Engagement of the primary stick shaker was very effective as a warning device and occurred at a margin that enabled the pilot to correct airplane attitude to regain the desired approach airspeed without encountering incipient stall characteristics.

## 2.2 TAKEOFF PERFORMANCE AND FLYING QUALITIES IN THE STOL CONFIGURATION

### 2.2.1 OBJECTIVE

Takeoff tests were conducted to determine the performance of the CV-2B airplane in the STOL configuration

### 2.2.2 METHOD

Takeoff tests were conducted to obtain curves of calibrated airspeed (CAS) at lift-off versus ground roll and calibrated airspeed at 50 feet versus total distance to an altitude of 50 feet. Each curve was obtained by conducting a series of takeoffs with various yoke-pull airspeeds. Different flap deflections were investigated to determine the optimum flap setting that would yield the shortest takeoff distance. During each series of takeoffs, ballast was added as fuel was consumed to maintain the test gross weight and C.G.

These tests were conducted over a pressure altitude range of 500 to 10,000 feet. All takeoff tests were conducted using takeoff power or maximum power available above the critical altitude of the engines. A ground operated Fairchild Flight Analyzer was used to produce a photographic record of time, horizontal distance and vertical distance for each takeoff. All takeoff tests were performed in winds of 5 knots or less.

2.2.3 RESULTS

Test results are presented graphically in Figures 5 through 14, and are summarized in Figures 1 through 4, Section 3, Appendix I.

2.2.4 ANALYSIS

2.2.4.1 General

Pilot-controlled parameters that affected takeoff flying qualities were as follows:

a. Takeoff flap setting.

b. Longitudinal control position during takeoff roll.

c. Longitudinal control application to initiate airplane rotation.

d. Longitudinal control positioning technique following lift-off.

Test data indicate that maximum STOL takeoff performance was obtained as flap settings of 30 degrees for gross weights less than 26,000 pounds and 25 degrees for gross weights greater than 26,000 pounds for all C.G. positions and altitudes tested. The evaluation of various flap settings to obtain the optimum flap settings was accomplished for all weights with the C.G. at the mid position. At this C.G. position, variation of the takeoff flap setting did not produce any significant change in the STOL takeoff trim settings.

2.2.4.2 Military Specification Compliance

Paragraph 3.3.11 of Military Specification MIL-F-8785 (ASG) (Reference 1.1.g) specifies that elevator effectiveness shall not unduly restrict the takeoff performance of the airplane. The CV-2B failed to meet this requirement. Reference to Table 5 shows that minimum nosewheel lift-off speed and takeoff ground roll distance varied as a function of C.G. position and gross weight. A comparison of these nosewheel lift-off speeds to the takeoff configuration stalling speeds presented in Table 4 further indicates that all minimum nosewheel lift-off speeds obtained were considerably higher than the free air stalling speeds obtained in the same configuration. These characteristics indicate that ground effect acting on the stabilizer/elevator caused a deterioration in longitudinal control effectiveness. Consequently, the airplane could not rotate into takeoff attitude until reaching a speed considerably above the stalling speed. This characteristic was undesirable because the maximum takeoff performance of the airplane could not be obtained.

TABLE 5. LIFT-OFF AIRSPEED AND GROUND ROLL SUMMARY

| Gross Weight lb | Center of Gravity % MAC | Flap Deflection deg | Minimum Nosewheel Lift-Off Speed KCAS | [illegible] |
|---|---|---|---|---|
| 22,000 | 32.9 | 30 | 50.5 | [illegible] |
| 26,000 | 29.3 | 30 | 62.0 | [illegible] |
| 26,000 | 34.2 | 30 | 58.0 | [illegible] |
| 26,000 | 39.0 | 30 | 54.5 | [illegible] |
| 28,500 | 31.0 | 25 | 65.0 | [illegible] |
| 28,500 | 35.0 | 25 | 61.5 | [illegible] |
| 28,500 | 39.0 | 25 | 59.0 | 650 |

The Operator's Manual (Reference 1.1.e) does not show the variation in ground roll takeoff distances that is obtained with changing C.G. position. The Operator's Manual (Reference 1.1.e) should include this information.

2.2.4.3 Longitudinal Control Force Gradients During Takeoff

Longitudinal control force gradients during the takeoff varied considerably with C.G. position. Approximately 3 to 5 pounds of pull force was required to maintain the control yoke against the aft stop while the airplane was static on the runway with the engines developing takeoff power. As airspeed increased during takeoff roll, aft pull force required to maintain a full aft yoke position increased so that as the airplane rotated the following estimated pull forces were required using contractor-recommended trim settings.

a. Heaviest pull force (28,500 pounds at 31.0 percent mean aerodynamic chord (MAC)) -45 pounds.

b. Lightest pull force (26,000 pounds at 39.0 percent MAC) - 10 pounds.

All longitudinal rotation forces obtained during this evaluation ranged between these extremes. The 45-pound pull force required in the heavy weight C.G. configuration required considerable pilot effort; however, because of the short period of time that the force was required and the fact that no difficulty was encountered in obtaining takeoff attitude, this force requirement was acceptable.

The 10-pound pull force required in the 26,000-pound aft C.G. configuration was too light for adequate pilot "feel," particularly when coupled with the high rotation rates obtained in this configuration. The light force combined with the high rate of rotation produced an uncomfortable tendency toward over-rotation. Longitudinal control force required for rotation with the C.G. in the aft position should be increased.

Longitudinal control forces required at all weights with the C.G. in the mid position were approximately 20 pounds at rotation and were satisfactory.

### 2.2.4.4 Takeoff Characteristics at Sea Level

STOL takeoff characteristics of the CV-2B at sea level were evaluated at the following test conditions:

TABLE 6. SEA LEVEL STOL TAKEOFF CONFIGURATION

| Gross Weight lb | Center of Gravity Position % MAC | Flap Setting deg |
|---|---|---|
| 22,000 | 32.9 | 25, 30, 35 |
| 26,000 | 29.3, 34.2, 39.0 | 25, 30 |
| 28,500 | 31.0, 35.0, 39.0 | 20, 25, 30 |

Maximum takeoff performance was obtained when the control yoke was positioned at the full-aft stop prior to commencing the takeoff roll. The control yoke was then maintained at the full-aft stop until the airplane rotated and lifted off. At this time the control was repositioned so that a desired climb-out attitude was obtained. The takeoff performance presented in Figures 1 through 14, Section 3, Appendix I, was obtained using this technique. Hereafter in this report this technique will be referred to as the "full-aft-yoke technique."

2.2.4.5 Full-Aft-Yoke Technique Takeoff Characteristics

2.2.4.5.1 Pre-Takeoff Checks and Runway Positioning

Pre-takeoff checks were easily completed and the takeoff checklist was adequate to prepare the airplane for a STOL takeoff.

2.2.4.5.2 Takeoff Ground Roll

Acceleration was very rapid upon brake release. Full-aft-control-yoke position was maintained by the copilot. Minimum rudder effectiveness was 35 - 40 KIAS at all flap settings. Nosewheel steering was used until the pilot transitioned from the nosewheel steering control to the control yoke to commence rotation.

2.2.4.5.3 Transition to Primary Controls

Approximately 5 knots below rotation speed, the pilot transitioned from the nosewheel steering control and took control of the yoke from the copilot. The CV-2B will become airborne below minimum single-engine control speed and minimum single-engine climb speed. The shift in primary control, just prior to STOL flight, was not conducive to continuity of control. To eliminate this shortcoming and to enable the pilot to retain control of all primary controls throughout the STOL takeoff maneuver, incorporation of the nosewheel power steering control into the rudder pedals is desirable.

2.2.4.5.4 Rotation and Lift-Off

Airplane lift-off occurred approximately 1 to 2 knots after nosewheel lift-off. Estimated time required for rotation from nosewheel lift-off to climb attitude was 2 seconds. The recommended lift-off speeds and speeds at an altitude of 50 feet are presented in Table 7.

| [illegible] Weight lb | Center of Gravity % MAC | $V_{LO}$* kt | $V_{50}$** kt | ΔV*** kt | $V_{50}/V_{LO}$ [illegible] % |
|---|---|---|---|---|---|
| 22,000 | 32.9 | 50.5 | 56.5 | 6.0 | 12 |
| 26,000 | 29.3 | 62.0 | 63.0 | 1.0 | 1.6 |
| | 34.2 | 58.0 | 59.5 | 1.5 | 2.6 |
| | 39.0 | 54.5 | 56.5 | 2.0 | 3.7 |
| 28,500 | 31.0 | 65.0 | 68.0 | 3.0 | 4.6 |
| | 35.0 | 61.5 | 65.0 | 3.5 | 5.7 |
| | 39.0 | 59.0 | 61.0 | 2.0 | 3.4 |

*$V_{LO}$ = Calibrated airspeed at lift-off

**$V_{5C}$ = Calibrated airspeed at 50 feet altitude

***ΔV = $V_{50}$ - $V_{LO}$

It was determined that use of the full-aft-yoke technique significantly enhanced the pilot's ability to obtain the recommended stabilized 50-foot airspeeds because of the simplified yoke positioning procedure.

Forward yoke deflections required to check rotation varied with C.G. position. At forward C.G. positions, a forward yoke deflection to a position of approximately neutral was required. At aft C.G. positions, a forward deflection to a position one-half to three-quarters forward of neutral was required. All required deflections were well within pilot capability and were easily obtained.

2.2.4.5.5 Climb Through 50 Feet

The climb characteristics of the CV-2B through 50 feet were satisfactory at the recommended airspeeds, with the exception of the condition previously discussed in Paragraph 2.1.4.2, "Takeoff Configuration Stalls."

2.2.4.5.6 Transition to Clean Configuration

The landing gear and flap retraction cycles were commenced immediately after lift-off and, since flap retraction occurred at the rate of approximately 1.5 degrees per second, transition to the clean climb configuration was in progress as the airplane passed through 50 feet. As flap retraction continued to zero deflection, a nose-down longitudinal trim change occurred while a constant climb attitude was maintained. The magnitude of the trim change varied with C.G. position. Aft stick force required at forward C.G. position was 15 to 20 pounds and considerable pilot effort was required to prevent the airplane from assuming a nose-down attitude. Correction of this shortcoming is desirable.

Longitudinal trim actuation to compensate for the pitch trim change was easily accomplished and was effective at all C.G. positions.

2.2.4.6 Miscellaneous Takeoff Characteristics

At all weights and C.G. positions tested, it was necessary to vary the takeoff technique from the optimum described in the preceding discussion to meet the lift-off and 50-foot airspeed requirements of this performance evaluation. With recommended flap settings, two additional flying qualities characteristics were noted when this technique was used:

a. Allowing the airplane to accelerate to speeds higher than the minimum nosewheel lift-off speed resulted in the airplane's rotating nose down on the runway so that the main landing gear began to lift clear off the ground. This characteristic was observed at the following gross weights and approximate indicated airspeeds:

(1) 22,000 pounds - 58 KIAS

(2) 26,000 pounds - 60 KIAS

(3) 28,500 pounds - 65 KIAS

b. With the C.G. in the aft position, both at 26,000 and 28,500 pounds, application of full-aft yoke from the neutral position at airspeeds in excess of the minimum nosewheel lift-off speed resulted in high rotation rates. This characteristic resulted in a tendency to over-rotate (zoom) the airplane and was very undesirable at the lower thrust-weight ratios obtained at altitudes above sea level. These high rotation rates were obtained at full-aft yoke application speeds approximately 5 knots higher than the minimum nosewheel lift-off speed for the weight being evaluated. Full-aft yoke should not be applied at speeds in excess of the minimum nosewheel lift-off speed with the C.G. in the aft position at any gross weight.

2.2.4.7 Takeoff Characteristics at Altitudes Above Sea Level

Due to the reduction in takeoff thrust available at altitude, it was necessary to vary the takeoff technique from the optimum used at sea level.

2.2.4.7.1 Takeoff Characteristics at 4000 Feet

At 4000 feet, testing was accomplished at a gross weight of 28,500 pounds with the C.G. at 35.0 percent MAC (mid) and at 39.0 percent MAC (aft).

At a mid C.G., the "full-aft-yoke technique" coupled with immediate flap retraction was successfully employed. The takeoff performance curves presented in Figure 8, Section 3, Appendix I, were obtained using this procedure. Use of this procedure resulted in no significant change in the takeoff characteristics from those obtained at sea level.

With the C.G. in the aft position, a change in the takeoff procedure was required to obtain favorable takeoff controllability characteristics.

As previously discussed, aft C.G. positions yielded rotation rates that were excessive, causing a pilot tendency to over-rotate the airplane to angles of attack higher than desired. These angles of attack produced an increase in airplane drag. At 4000 feet there was insufficient power to obtain a continuous positive rate of climb while simultaneously accelerating the airplane to compensate for loss of lift due to flap retraction.

To obtain consistently favorable takeoff characteristics and maximum performance with the C.G. in the aft position, flap retraction following "full-aft-yoke technique" lift-off was delayed until an airspeed of approximately 70 KIAS was obtained. The remainder of the takeoff technique was as descirbed for sea level. It is recommended that the procedure outlined in this paragraph be incorporated in the Operator's Manual (Reference 1.1.e).

2.2.4.7.2 Takeoff Characteristics at 6000 Feet

At 6000 feet, testing was accomplished at the conditions listed in Table 8:

TABLE 8. TAKEOFF CONFIGURATION [illegible]

| Gross Weight lb | Center of Gravity % MAC | Flap Setting deg |
|---|---|---|
| 22,000 | 32.9 | 30 |
| 26,000 | 34.2 | 30 |
| 27,000 | 34.5 | 25, 30 |
| 28,500 | 31.0, 35.0, 39.0 | 25 |

2.2.4.7.2.1 <u>Takeoff Characteristics at 6000 Feet for a Gross Weight of 22,000 and 26,000 Pounds</u>

At these weights, with the C.G. in the mid position, the "full-aft-yoke technique" coupled with immediate flap retraction, as developed at sea level, could be employed. This takeoff procedure was used to obtain the maximum takeoff performance data presented in Figures 8 and 10, Section 3, Appendix I, and is recommended for use at this altitude.

Insufficient testing was accomplished to determine a recommended procedure when operating the CV-2B at 26,000 pounds with the C.G. in the aft position at an altitude of 6000 feet.

2.2.4.7.2.2 <u>Takeoff Characteristics at 6000 Feet for a Gross Weight of 27,000 Pounds</u>

Evaluation of the STOL takeoff characteristics of the CV-2B at this weight and altitude was necessary to define the change in takeoff characteristics between 26,000 pounds and 28,500 pounds. The results of testing at 26,000 pounds, as presented in Paragraph 2.2.4.7.1, indicated that this was the maximum weight, at 6000 feet, at which consistent maximum takeoff performance could be obtained using the "full-aft-yoke technique" coupled with an immediate flap retraction.

To determine the procedure and flap configuration that would produce acceptable takeoff characteristics at weights between 26,000 pounds and 28,500 pounds, testing was accomplished at 27,000 pounds with the C.G. at 34.5 percent MAC (mid) using two takeoff flap settings, 25 and 30 degrees. The results of these tests are shown in Figures 11 and 12, Section 3, Appendix I. Maximum takeoff performance at 27,000 pounds was obtained with a takeoff flap setting of 25 degrees.

At 27,000 pounds, with the C.G. in the mid position, it was necessary to delay the flap retraction sequence. This procedure coupled with the "full-aft-yoke technique" produced satisfactory takeoff characteristics. This technique was used to obtain the takeoff performance curves presented in Figure 13, Section 3, Appendix I.

The Operator's Manual (Reference 1.1.e) should be modified to include the takeoff procedures recommended in the preceding paragraph.

2.2.4.7.2.3 Takeoff Characteristics at 6000 Feet for a Gross Weight of 28,500 Pounds

At this weight, testing was conducted with the C.G. at the mid (35.0 percent MAC), forward (31.0 percent MAC) and aft (39.0 percent MAC) positions.

Complete STOL takeoff performance data were obtained for the mid C.G. position only. Testing at the forward and aft C.G. positions was accomplished to check the variation in takeoff characteristics resulting from a shift in C.G. and was very limited in scope.

With the C.G. in the mid position, favorable takeoff characteristics were obtained using the "full-aft-yoke technique" coupled with a two-step, delayed flap retraction. The takeoff performance curves presented in Figure 13, Section 3, Appendix I, were obtained using this procedure.

At this weight and altitude, a one-step flap retraction did not provide sufficient continuity in rate of climb and acceleration throughout the transition from the STOL takeoff configuration to the clean climb configuration.

Flap retraction in two steps, therefore, was evaluated and produced the desired results. Initial flap retraction to 15 degrees was commenced after the airplane had climbed through 50 feet at the stabilized recommended airspeed. Holding a constant attitude, the airplane was then allowed to accelerate to 70 - 75 KIAS where flap retraction was continued from 15 degrees to 0 degrees. This flap retraction procedure when coupled with the "full-aft-yoke technique" produced a satisfactory takeoff flight path and transition and is recommended for use at this weight - altitude combination.

With the C.G. in the forward position (31.0 percent MAC), satisfactory takeoff characteristics could be obtained using the "full-aft-yoke technique" coupled with a two-step flap retraction.

With the C.G. in the aft position (39.0 percent MAC), maximum STOL takeoff performance comparable to that at the mid and forward C.G. positions could not consistently be obtained. This was due to the high rotation rates at lift-off and the low control forces. Takeoff procedures evaluated for this configuration were the "full-aft-yoke technique" coupled with a delayed flap retraetion.

Power available at this altitude was reduced, causing a deterioration in takeoff characteristics. This deterioration was similar to that obtained at the same weight at 4000 feet when using an immediate flap retraction.

It is recommended that STOL takeoffs not be executed in this weight (28,500 pounds) and aft C.G. configuration at altitudes of 6000 feet and higher and that an appropriate "caution" note be included in the Operator's Manual (Reference 1.1.e).

2.2.4.7.3 Takeoff Characteristics at 10,000 Feet

At this altitude, testing was conducted at a gross weight of 22,000 pounds with the C.G. in the mid position (32.9 percent MAC) using an optimum STOL takeoff flap setting of 30 degrees.

The takeoff performance curves presented in Figure 15, Section 3, Appendix I, were obtained using the "full-aft-yoke technique" combined with a delayed flap retraction. This procedure is recommended for use at this altitude-gross weight-C.G. configuration.

2.2.4.8 Summary of Takeoff Characteristics

The results of this takeoff evaluation, within the scope tested, are summarized in Table 9. (Table 9 on next page).

## 2.3 SAWTOOTH CLIMBS

### 2.3.1 OBJECTIVE

Sawtooth climbs were conducted to determine the optimum airspeed climb schedule for specified gross weights that should be used during the continuous climb tests.

### 2.3.2 METHOD

Sawtooth climbs were conducted at various test altitudes using normal rated power or maximum power available. Each climb was started sufficiently below the test altitude so that stabilized conditions were obtained. The climbs were flown cross wind to eliminate wind gradient effects.

The sawtooth climbs were conducted at 28,500 pounds and 31,300 pounds at a mid C.G. location.

The data were corrected to standard atmospheric weight conditions.

### 2.3.3 RESULTS

The results of the climb performance tests are presented graphically in Figures 17 and 18, Section 3, Appendix I.

### 2.3.4 ANALYSIS

The sawtooth climb tests revealed that the present continuous climb schedule shown in the Operator's Manual (Reference 1.1.e) is not optimum at all gross weights. This schedule, when followed, did not greatly affect the climb performance at 26,000 pounds and 28,500 pounds. This schedule caused some

TABLE 9. SUMMARY OF TAKEOFF TEST RESULTS

| Gross Weight lb | Altitude Range ft | Center of Gravity Range % MAC | Flap deg | Procedure Recommended | Takeoff Characteristics Results | Envelope Limits |
|---|---|---|---|---|---|---|
| 22,000 | SL-6000 | 26.7-32.9 | 30 | F.A.*+I.R.** | Satisfactory | STOL takeoffs at all weights up to 22,000 lb; aft C.G. not recommended at any altitude |
| 22,000 | 7000 - 10,000 | 26.7-32.9 | 30 | F.A.+D.R.*** | Satisfactory | Same as above |
| 26,000 | SL-3000 | 29.3-39.0 | 30 | F.A.+I.R. | Satisfactory | None |
| 26,000 | 4000-6000 | 29.3-34.2 | 30 | F.A.+I.R. | Satisfactory | STOL takeoffs at this weight; aft C.G. not recommended above 3000 ft. |
| 27,000 | SL-3000 | 30.0-39.- | 25 | F.A.+I.R. | Satisfactory | None |
| 27,000 | 4000-6000 | 30.0-34.5 | 25 | F.A.+D.R. | Satisfactory | STOL takeoffs at this weight; aft C.G. not recommended at altitudes in excess of 3000 ft. |
| 28,500 | SL-3000 | 31.0-39.0 | 25 | F.A.+I.R. | Satisfactory | None |
| 28,500 | 4000-6000 | 31.0-35.0 | 25 | F.A. + 2-step D.R. | Satisfactory | STOL takeoffs at this weight; aft C.G. not recommended at altitudes in excess of 4000 ft. |

*F.A. - Full-aft-yoke technique
**I.R. - Immediate flap retraction
***D.R. - Delayed flap retraction

decrease in performance at 22,000 pounds and 31,300 pounds. See Figures 19 and 21, Section 3, Appendix I, for the recommended climb airspeed schedule. A comparison of the continuous climb data and the sawtooth data showed good agreement.

## 2.4 CONTINUOUS CLIMBS

### 2.4.1 OBJECTIVE

Continuous climb tests were conducted to determine the performance during climbing flight and the service ceiling for both single- and two-engine operation.

### 2.4.2 METHOD

Two-engine continuous climb performance tests were conducted from near sea level to service ceiling using normal rated power. These continuous climbs were conducted at gross weights of 22,000, 28,500 and 31,300 pounds at a mid C.G. location. During the climb, power was maintained at limit manifold pressure until full throttle was obtained at the engines' critical altitude.

Single-engine continuous climbs were performed with the left engine feathered and the right engine developing normal rated power up to critical altitude at 28,500 and 31,300 pounds.

The data were corrected to standard atmospheric and weight conditions.

### 2.4.3 RESULTS

The results of the continuous climb performance tests are presented graphically in Figures 19 through 23, Section 3, Appendix I.

### 2.4.4 ANALYSIS

The maximum rate of climb, critical altitude and service ceiling for each gross weight tested are presented in Table 10.

| [illegible] | | | |
|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] |
| 22,000* | 1760 | 7200 | [illegible] |
| 28,500* | 1200 | [illegible] | [illegible] |
| 31,300* | 930 | 7400 | [illegible] |
| 28,500** | 125 | 7300 | [illegible] |
| 31,300** | *** | *** | *** |

*Normal rated power both engines
**Normal rated power right engine with left engine feathered
***Positive rate of climb not obtainable
****Engine critical altitude is affected by the climb schedule airspeed

The climb airspeed schedule used during this test program was derived from the sawtooth climbs and cross-checked with the level flight data for each gross weight. The airspeed schedule for each gross weight did not agree with that in the Operator's Manual (Reference 1.1.e).

The climb airspeed schedule was easy to establish and maintain at all gross weights and altitudes except at 22,000. At 22,000 pounds, the attitude of the airplane was nose high, restricting the pilot's field of vision and providing virtually no fixed horizon for airplane attitude reference.

The single-engine climb performance in the clean configuration is also presented at climb start gross weights of 28,500 pounds and 31,300 pounds. With the left engine feathered and the right engine operating at normal rated power, the single-engine service ceiling at 28,500 pounds was found to be 7300 feet. This altitude is close to the normal rated power critical altitude. If the engine will not develop normal rated power due to deterioration and the service ceiling falls below the critical altitude, the net effect will be to reduce the service ceiling to below sea level. This will occur because sufficient power to maintain level flight will not be available at any altitude below the critical altitude. At 31,300 pounds, the CV-2B had no single-engine climb or level-flight capability with a single engine developing normal rated power.

## 2.5 LEVEL FLIGHT

### 2.5.1 OBJECTIVE

Level flight tests were conducted to determine power required and range performance. These tests were conducted during two-engine and single-engine operation.

### 2.5.2 METHOD

Level flight tests were conducted over a range of pressure altitudes from 2000 to 15,000 feet and at gross weights from 22,000 pounds to 31,300 pounds (mid C.G. location). The test data were gathered while maintaining a constant $Wt/\delta$ relationship. This required an altitude increase as fuel was consumed. The data were recorded at stabilized test points throughout the allowable speed range.

### 2.5.3 RESULTS

The results of the level flight performance tests are presented graphically in Figures 24 through 49, Section 3, Appendix I.

### 2.5.4 ANALYSIS

The maximum airspeed in level flight was limited by the engine's brake mean effect pressure limit above the critical altitude for normal rated power.

The maximum endurance airspeeds achieved during this test program did not agree with the recommended maximum endurance data presented in the Operator's Manual (Reference 1.1.e). The differences increased with increasing altitude. The Operator's Manual should be corrected if maximum endurance is to be realized.

During this program, the nautical air mile per pound of fuel (NAMPP) data were in agreement with the data presented in the Operator's Manual (Reference 1.1.e). The level-flight cruise data are summarized in Table 11.

**TABLE 11. SUMMARY OF LEVEL-FLIGHT CRUISE DATA**

| Altitude ft | Gross Weight lb | Recommended Cruise KTAS | Maximum NAMPP | Brake Horsepower per engine | Engine Mixture Setting |
|---|---|---|---|---|---|
| 2,000 | 28,500 | 121.0 | .2630 | 491 | Lean |
| 5,500 | 28,500 | 129.5 | .2680 | 526 | Lean |
| 8,000 | 28,500 | 133.0 | .2685 | 537 | Lean |
| 10,000 | 28,500 | 137.0 | .2693 | 554 | Lean |
| 12,500 | 28,500 | 141.0 | .2680 | 568 | Lean |
| 15,000 | 28,500 | 145.0 | .2610 | 577 | Lean |
| 10,000 | 22,000 | 128.0 | .3100 | 418 | Lean |
| 5,500 | 26,000 | 126.0 | .2790 | 477 | Lean |
| 8,000 | 26,000 | 126.0 | .2840 | 463 | Lean |
| 10,000 | 31,300 | 141.0 | .2500 | 619 | Lean |

Level flight tests were also flown with the aft cargo and ramp doors open to various positions to determine the effects on power required and range performance. The effects of the three cargo door positions investigated (See Photographs 1, 2 and 3) are presented in Table 12.

**TABLE 12. SUMMARY OF DATA FOR LEVEL-FLIGHT TEST WITH CARGO AND RAMP DOORS OPEN**

| Condition | Ramp Door | Cargo Door | Photograph No. | $C_{do}$* Increase | Increase In Power Required % | Decrease In Range % |
|---|---|---|---|---|---|---|
| A | Up | Open | 1 | .0017 | 5.5 | 3.5 |
| B | Down 15° | Open | 2 | .0041 | 11 | 8.5 |
| C | Down 30° | Open | 3 | .0080 | 21.4 | 12.2 |

*Airplane parasite drag coefficient

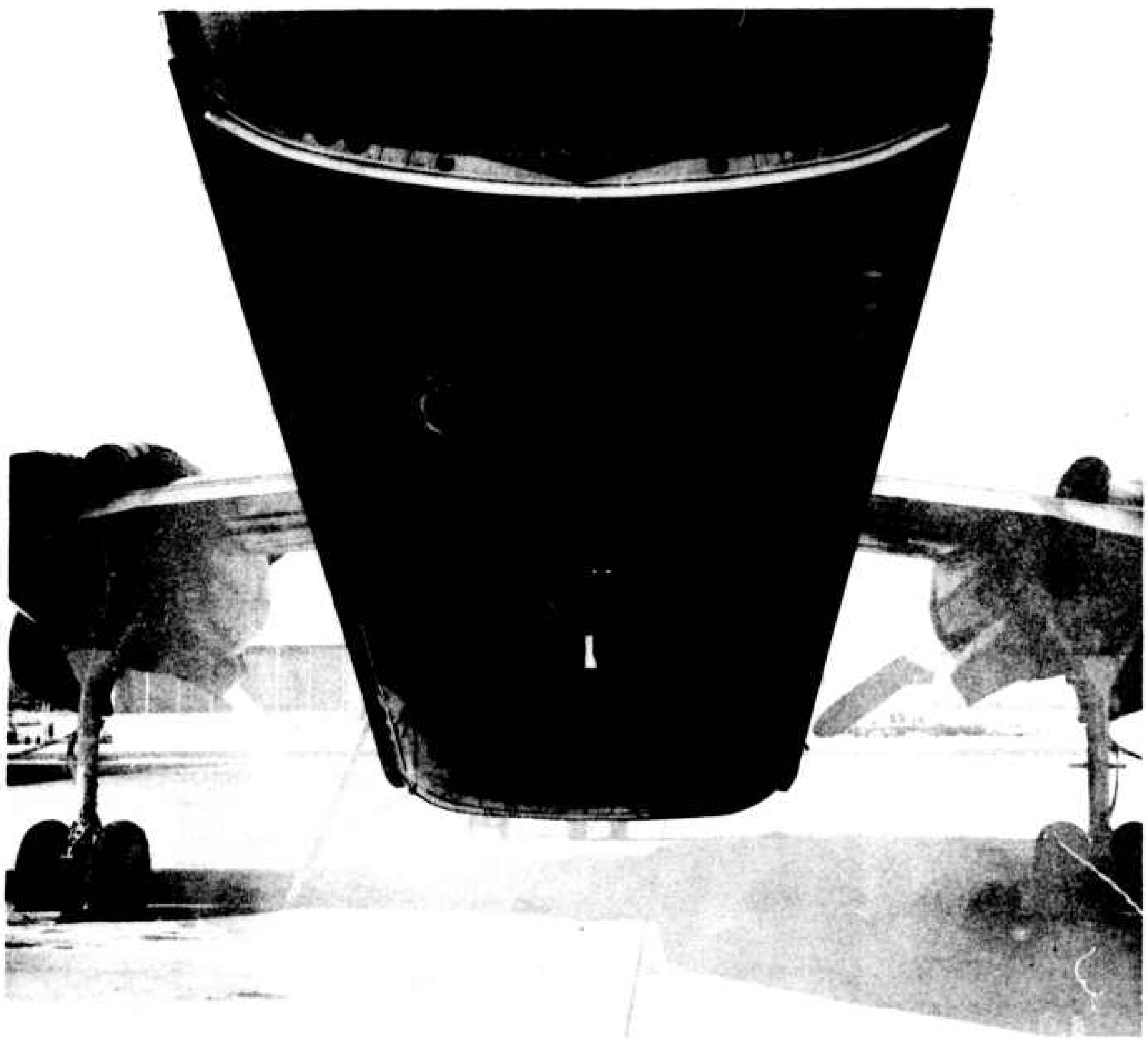


PHOTO NO.1 – CARGO DOOR OPEN and RAMP DOOR UP

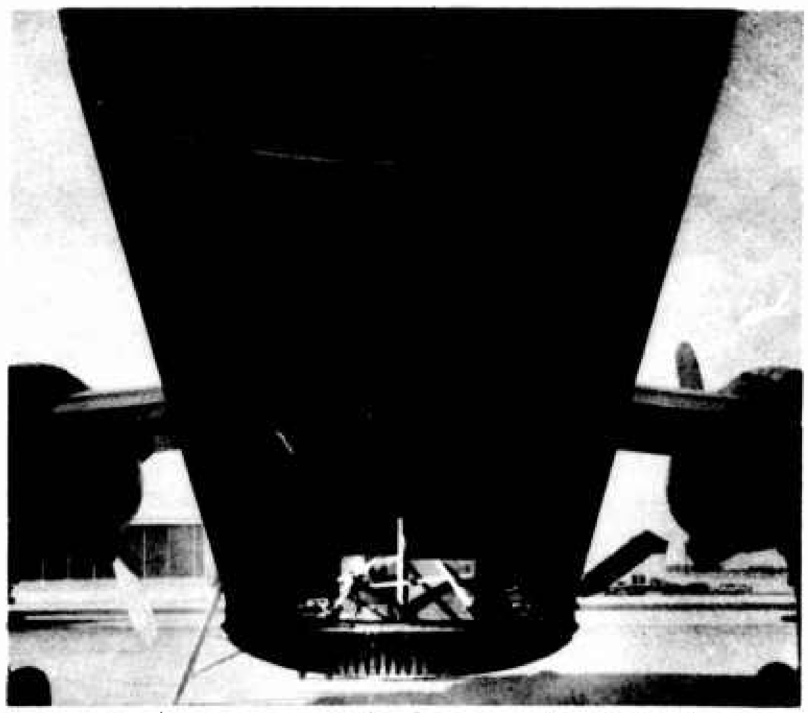


**PHOTO NO.2 – CARGO DOOR OPEN and RAMP DOOR DOWN 15°**

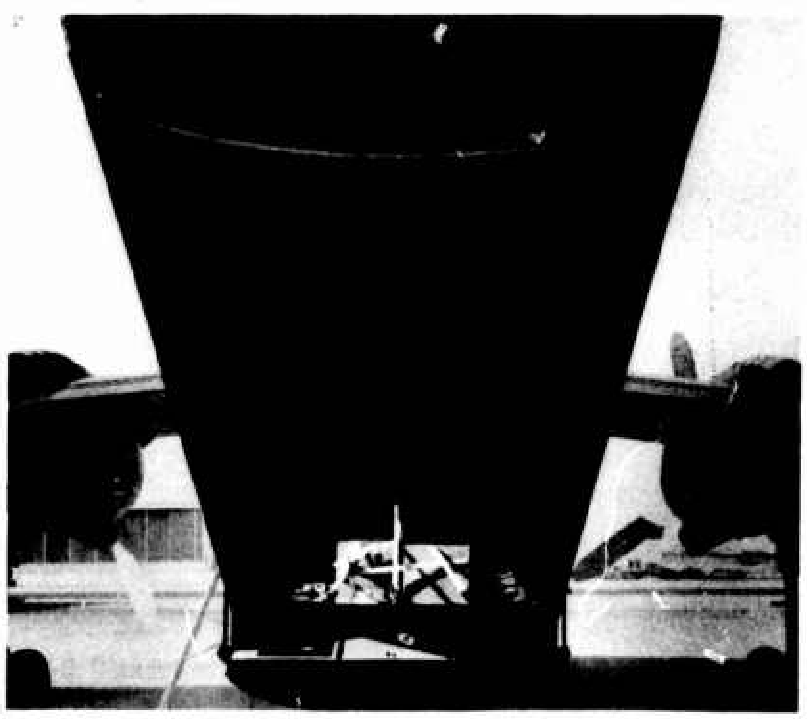


**PHOTO NO.3 – CARGO DOOR OPEN and RAMP DOOR DOWN 30°**

Moderate buffet was noted in the empennage when the cargo ramp was lowered below the 15-degree position (Condition B). This was the only flying quality change noted during three level flight tests.

Level-flight data with the left propeller feathered indicated maximum NAMPP to be .15 at 113 knots at 2000 feet for a gross weight of 28,500 pounds. Level flight was impossible with a windmilling propeller because the power required was greater than the normal rated horsepower (1220 horsepower) available. Single-engine level flight tests were not conducted at 31,300 pounds since the power required for level flight was greater than the normal rated horsepower (1220 horsepower) available.

## 2.6 LANDING PERFORMANCE AND FLYING QUALITIES IN THE STOL CONFIGURATION

### 2.6.1 OBJECTIVE

Landing tests were conducted to determine the performance of the CV-2B airplane in the STOL configuration.

### 2.6.2 METHOD

Landing tests were conducted to obtain curves of calibrated airspeed (CAS) at touchdown versus ground roll and calibrated airspeed at 50 feet versus total distance from 50 feet. Each curve was obtained by conducting a series of landings using various approach airspeeds. Several landings were made using minimum approach airspeed. During each series of landing, ballast was added as necessary to maintain the test gross weight and C.G. as fuel was consumed.

These tests were conducted over a pressure altitude range of 500 feet to 10,000 feet. A ground operated Fairchild Flight Analyzer was used to produce a photographic record of time, horizontal distance, and vertical distance for each landing. All landing tests were performed in winds of 5 knots or less.

### 2.6.3 RESULTS

Test results are presented graphically in Figures 51 through 57, and are summarized in Figure 50, Section 3, Appendix I.

## 2.6.4 ANALYSIS

### 2.6.4.1 General

Landing flying qualities characteristics were evaluated in conjunction with the STOL landing performance characteristics under the conditions in Table 13:

TABLE 13. STOL LANDING TEST CONDITIONS

| Gross Weight lb | Center of Gravity % MAC | Pressure [illegible] |
|---|---|---|
| 22,000 | 32.9 | Sea Level, [illegible] |
| 26,000 | 29.3 | Sea [illegible] |
| 26,000 | 34.2 | Sea [illegible] |
| 26,000 | 39.0 | Sea [illegible] |
| 28,500 | 31.0 | Sea [illegible] |
| 28,500 | 35.0 | Sea Level, [illegible] |
| 28,500 | 39.0 | Sea Level, [illegible] |

As gross weight, C.G. and landing altitude were varied no change in landing technique or landing configuration was required to obtain the maximum STOL landing performance available.

The following airplane configuration was used for all STOL landings:

a. Landing Gear - Down

b. Flaps - 40 degrees

c. Throttles - Idle

d. Propeller Controls - Takeoff rpm setting

e. Mixtures - Auto rich

f. Carburetor Heat - Cold

g. Auto - feathering - Off

h. Nosewheel Steering - On

i. Trim - For desired approach speed

j. Ramp and Cargo Doors - Closed

At each combination of conditions tested in Table 13, STOL landing characteristics were evaluated with and without use of reverse thrust as required to obtain the necessary data.

2.6.4.2 Landing Approach Technique

Based on previous CV-2B engineering tests (References 1.1.b, 1.1.c, and 1.1.d) it was determined that a power-off versus power-on STOL approach would yield maximum STOL landing performance over a 50-foot barrier. This approach technique, essentially as described in the Operator's Manual (Reference 1.1.e) was used throughout this evaluation.

2.6.4.3 Landing Approach Airspeed Stabilization Technique

The approach airspeed stabilization technique used in this evaluation was developed in order to obtain the maximum STOL landing performance available in the CV-2B airplane.

Wind shear gradients exist from the surface up to altitudes encompassing the STOL approach sequence. In order to achieve a stabilized 50-foot airspeed, it was necessary to maintain a constant approach attitude. It was observed, however, that when the pilot stabilized at the desired indicated airspeed upon initiating the approach (at 800 to 1000 feet) there was a tendency to make attitude changes during the remainder of the approach down to the height at which the landing flare was commenced. This tendency was due to pilot observation of momentary indicated airspeed excursions. These excursions in indicated airspeed were, in turn, caused by the wind shear gradient.

To alleviate the wind shear effects, a change in the approach technique was developed. The airplane was initially stabilized at an indicated airspeed sufficiently in excess of the desired 50-foot approach speed so that as the approach was executed at a constant attitude, wind shear effects caused the indicated airspeed to bleed down to the desired values as the airplane passed through 50 feet without any further pilot control inputs. Since this technique was easy to execute and produced consistent landing results, it was used to obtain the STOL landing performance data presented in Figures 51 through 57, Section 3, Appendix I. This technique is recommended for use whenever feasible.

2.6.4.4 Landing Flare Technique

The landing flare technique developed in this evaluation reduced "float" to a minimum, thereby permitting the earliest possible use of braking action to reduce landing distances.

At the 50-foot approach airspeeds recommended in this report, the landing flare was commenced at a height of approximately 30 feet. This height allowed sufficient time for the pilot to flare the airplane into a stalled attitude, thus attaining maximum available lift and the desired reduction in sink rate prior to ground contact. At the recommended approach airspeeds, there was insufficient [illegible] to cause "float."

At 50-foot approach airspeeds higher than those recommended in this report, flare technique to produce early ground contact at an acceptable sink rate was more difficult because of "float" tendencies due to the excess lift available. To preclude inadvertent "floating," therefore, it is recommended that airspeeds in excess of the recommended values not be utilized.

2.6.4.5 Landing Characteristics

The standard airspeed indicator inatalled in the CV-2B is marked in 5-knot increments. This degree of resolution was unsatisfactory considering the effect of 5-knot airspeed variation on landing distances. Reference to Figures 51 through 57, Section 3, Appendix I, shows that an increase of 5 knots at 50 feet produced an increase in landing distances of from 250 to 350 feet, depending on the gross weight. This variation was approximately 25 percent of the total distance required at the recommended 50-foot airspeeds. To enhance pilot ability in obtaining the maximum landing performance at recommended airspeeds, it is desirable to install sensitive airspeed indicators with airspeed marked in 1-knot increments in all CV-2B airplanes.

A "Safe-Flight" approach indicator was also installed in the test airplane. This instrument was unsatisfactory as a primary approach reference. Location of the instrument on the pilot's panel was satisfactory for peripheral viewing. The instrument, however, was not responsive enough to variations in angle of attack caused by the wind shear gradient; this detracted from the pilot's ability to make quick, precise attitude corrections. In addition, the instrument was indexed for three weights only: 23,000, 26,000 and 28,500 pounds. No additional references in the relatively wide range between these indexes were provided. The pilot had relatively little "feel" for the degree of correction required to obtain desired attitudes. This was important because there was only a 4-knot differential in the recommended approach speeds for 26,000 and 28,500 pounds. Further study is recommended for the development of an angle-of-attack indicator with appropriate sensitivity and presentation that can be utilized for all flight conditions.

Stability and control characteristics during the approach were generally unsatisfactory at all C.G. positions and detracted from the pilot's ability to obtain the constant attitudes required for maximum performance. This was due primarily to weak static longitudinal and static directional stability, weak lateral and directional control power, weakly negative dihedral effect, poor control harmony and weakly damped dynamic lateral-directional oscillations.

Pilot "feel" for the desired longitudinal trim position was degraded by the slightly positive static longitudinal stability gradients and by the masking of the longitudinal gradients by control system friction. This characteristic was undesirable as continuous pilot attention was required to prevent inadvertent pitch attitude changes.

Pilot "feel" for balanced (ball-centered) flight was degraded by the weak static directional stability characteristics of the airplane and by the masking of the directional gradients by control system friction. This was undesirable because continuous pilot attention was required to prevent the development of inadvertent sideslips with resulting runway misalignment.

Low lateral and directional control power, coupled with slightly positive static directional stability gradient, resulted in a requirement for continuous, large-displacement lateral control inputs to maintain runway alignment and wings-level flight. This requirement was aggravated by the negative dihedral effect characteristics of the airplane since rudder could not be used to keep the wings level. Full lateral control deflections with rudder pedals fixed produced bank angles of 8 to 9 degrees to the left and 7 to 8 degrees to the right in 1 second. This degree of control effectiveness did not comply with the requirements of Military Specification MIL-F-8785 (Reference 1.1.g) and was inadequate, particularly in turbulent air.

Poor control force harmony was also observed in this configuration. Military Specification MIL-F-8785 states that, as a guide, the ratio of control forces should be 2:7:1 for elevator, rudder and aileron respectively. In the CV-2B, lateral control forces were relatively high and directional control forces were relatively low. This characteristic was not satisfactory, particularly in view of the large lateral inputs required. An improvement in control harmony in the CV-2B is desirable.

The weak damping of lateral-directional oscillations was unsatisfactory because these oscillations interfered with the pilot's ability to maintain alignment with the runway. This characteristic is particularly significant in rough air. Combined with low control power, these oscillations, in a yaw-roll ratio of approximately 4:1, required large directional control inputs to maintain steady-heading flight. These inputs, in turn, produced lateral coupling which necessitated lateral inputs. Additionally, airspeed position error changes caused by the transient sideslips produced fluctuations in the indicated airpseed. These characteristics, when combined, placed excessive demands on the pilot during a critical portion of the STOL approach (i.e., airspeed stabilization prior tc flaring). Improved damping of lateral-directional oscillations is very desirable.

Landing attitude, once obtained, was maintained until touchdown occurred. At recommended approach speeds, this produced primary stick shaker activation, following almost immediately by the stall and ground contact in an attitude of 15 to 20 degrees nose high. At the highest touchdown speeds tested, attitude at touch down was very near level. In the CV-2B airplane, touchdown at speeds in excess of 8 to 10 knots above the nominal recommended touchdown speeds is not recommended due to the possibility of initial ground contact on the nosewheel.

Using the 50-foot approach speeds recommended in this report coupled with a full-aft-yoke flare generally produced touchdown sink rates ranging from 5 to 9 feet per second. Limit landing sink rate for the CV-2B is 13 feet per second. Fifty-foot airspeeds lower than those recommended in this report are not recommended because of the probability of producing excessively high landing sink rates.

During landings when reversing was not used, upon ground contact on the main gear, the pilot relaxed aft control pressure a sufficient amount to cause the nosewheel to contact the ground and began symmetrical braking action while maintaining directional control with nosewheel steering. Braking was applied essentially as described in the Operator's Manual (Reference 1.1.e).

2.6.4.5.1 Landing Characteristics During Roll-Out (Using Propeller Reversing)

During landings using propeller reversing, upon obtaining ground contact on the main gear, the pilot selected the reverse thrust position with the throttles and applied full power. Maintaining the yoke full aft until after nosewheel ground contact resulted in acceptable nosewheel impact forces. Simultaneously with the selection of reverse thrust, the pilot applied maximum braking.

It is estimated that, at sea level, a period of approximately 3 seconds was required for the engines to peak at maximum power in reverse. At higher landing altitudes, however, engine acceleration characteristics deteriorated. At 6000 feet, engine acceleration was such that maximum rpm was not reached until after the airplane decelerated to a stop. This was undesirable as it was not possible to utilize the maximum reversing action.

2.6.4.6 Landing Summary

The STOL landing characteristics obtained within the scope of this evaluation did not vary significantly as a result of changing gross weight, C.G., or altitude. A stabilized attitude, full-flap, power-off approach was successfully used to obtain maximum performance in all configurations tested.

Trim change characteristics and flying qualities of the CV-2B airplane in the STOL landing configuration detracted from pilot ability to obtain consistent maximum landing performance.

The installation of reverse thrust in the CV-2B significantly improved landing performance was easy to use; however, reverse thrust effectiveness deteriorated at higher altitudes.

## 2.7 AIRSPEED CALIBRATION

### 2.7.1 OBJECTIVE

The objective of these tests was to determine the airspeed position error for both the standard and test airspeed systems in the cruise and STOL configuration.

### 2.7.2 METHOD

The airspeed calibration of the standard and test systems was determined by using the ground speed course method. The airplane was flown over a measured course at various stabilized airspeeds on reciprocal headings. Airspeeds from approximately 50 to 170 KCAS in 10-knot increments were flown.

### 2.7.3 RESULTS

The results of the airspeed calibrations are presented graphically in Figures 59 and 60, Section 3, Appendix I.

An additional position error calibration in ground effect is presented in Figures 15 and 16, Section 3, Appendix I. This calibration was obtained during the takeoff and landing tests.

### 2.7.4 ANALYSIS

The standard system position error was nonlinear, with an increase in positive position error as airspeed was increased. This position error decreased as the flaps were lowered in an out-of-ground-effect flight condition. The position error, however, remained positive for all flap settings except at 40 degrees.

# SECTION 3

## Appendix I

TEST DATA

Figure No. 1
Take-off Summary
CV-2B S/N 62-4175
Dry Concrete Runway
Engine Model R-2000-7M2
Center of Gravity (Mid) C.G.
Standard Day Conditions
Take-off Power
STOL Technique

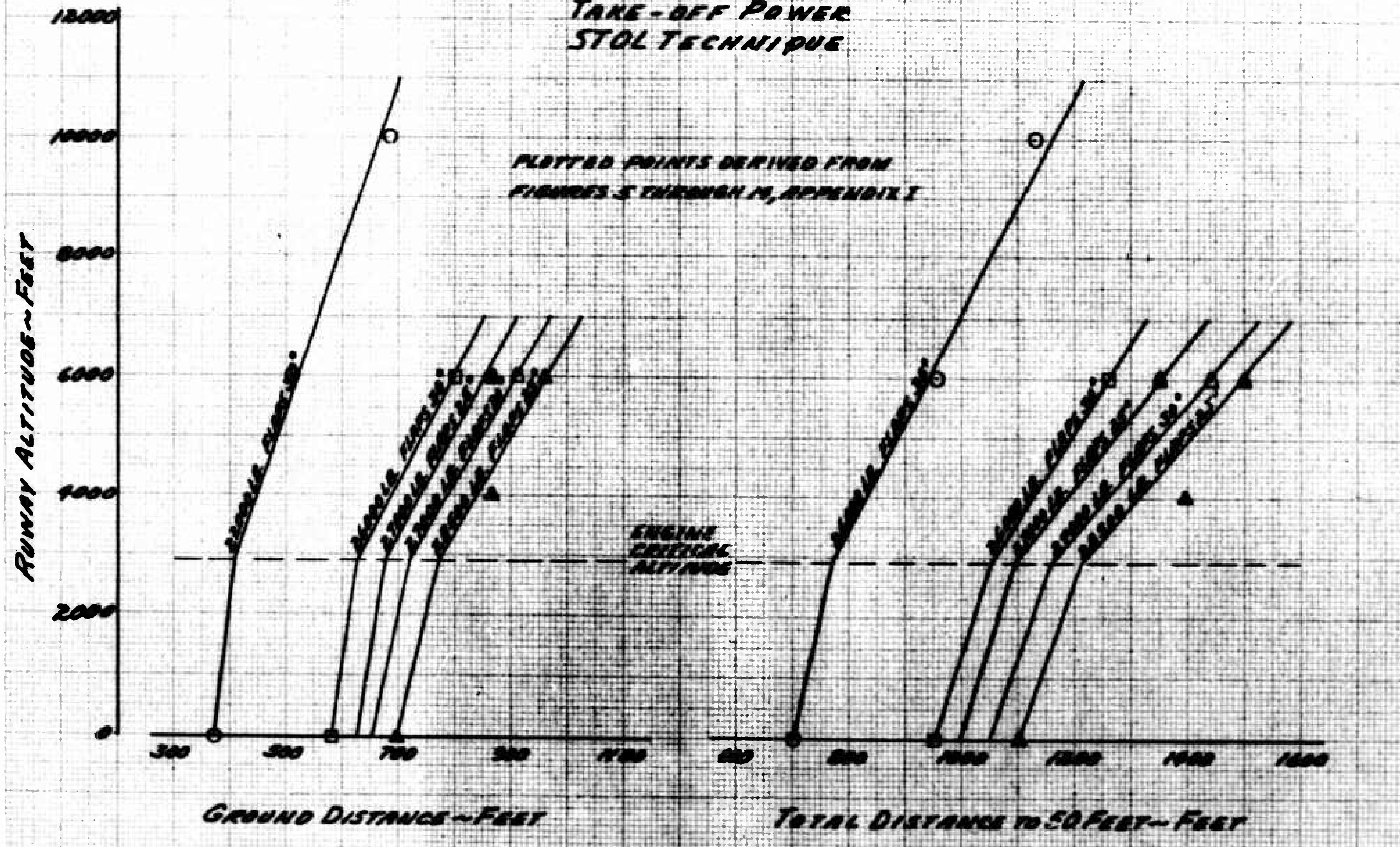


FIGURE No. 2

EFFECT OF CENTER OF GRAVITY ON TAKE-OFF DISTANCE

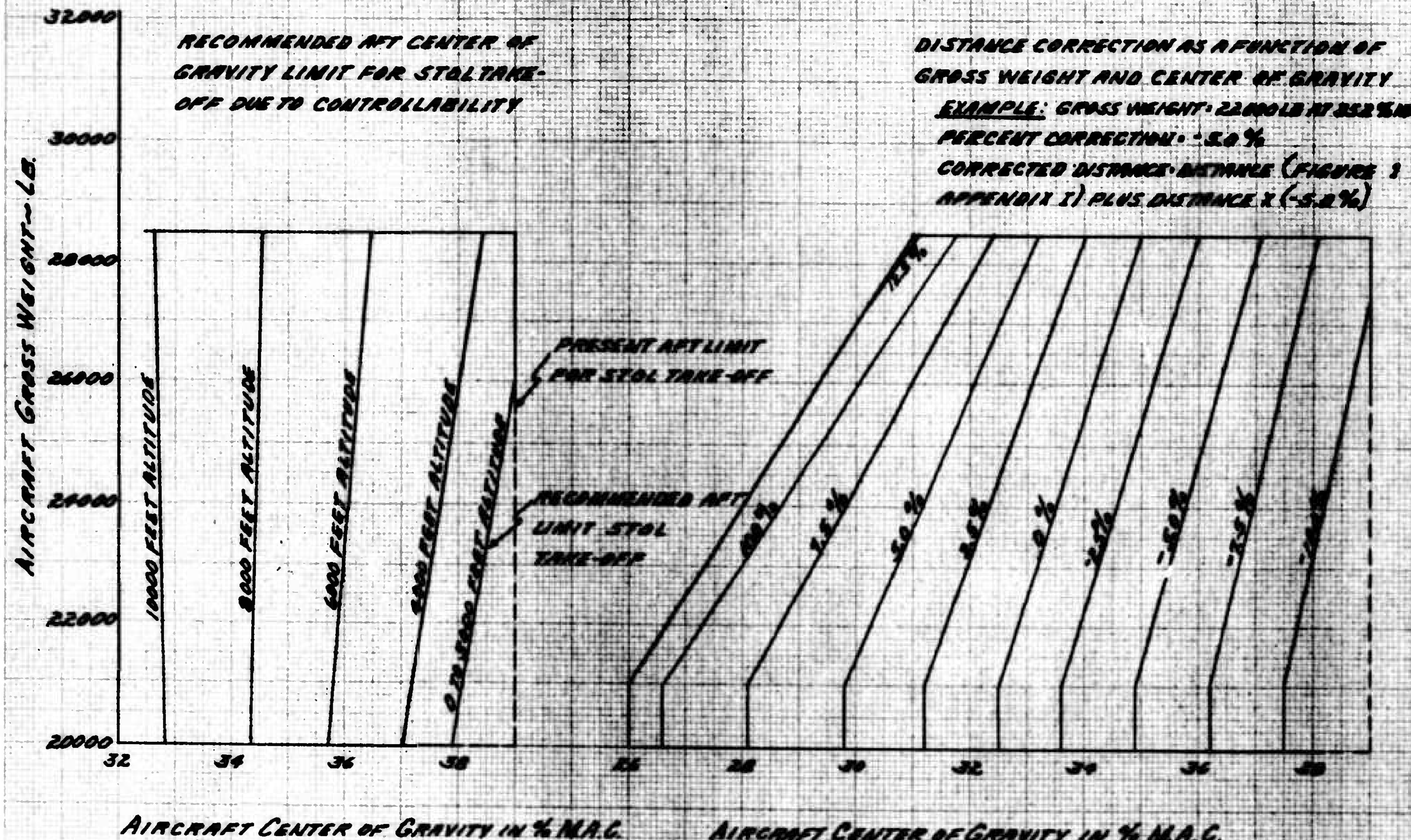
CV-2B S/N 62-4175

DRY CONCRETE RUNWAY

ENGINE MODEL R-2000-7M2

TAKE-OFF POWER

STOL TECHNIQUE



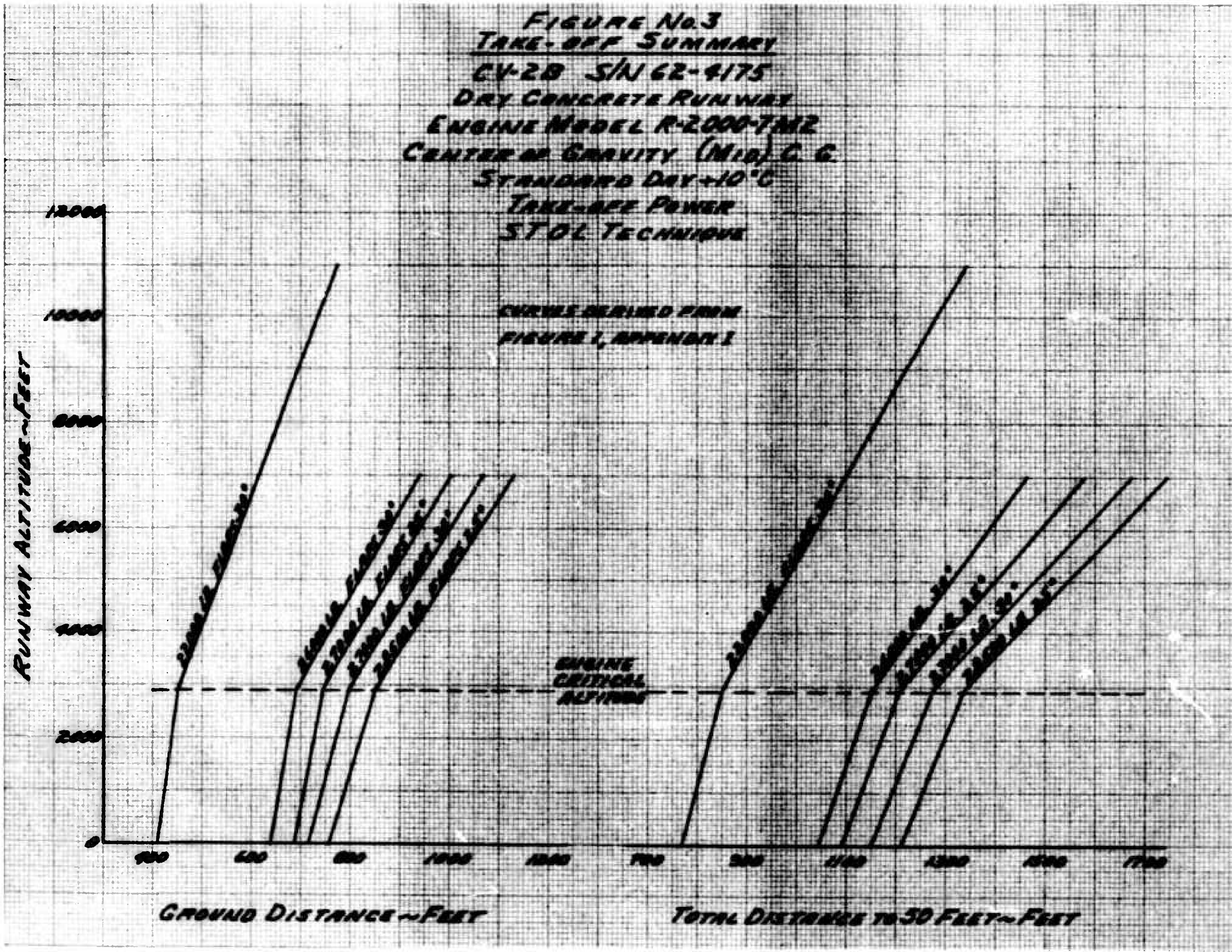


FIGURE No.3
TAKE-OFF SUMMARY
CV-2B S/N 62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
CENTER OF GRAVITY (MID) C. G.
STANDARD DAY +10°C
TAKE-OFF POWER
STOL TECHNIQUE
CURVES DERIVED FROM
FIGURE 1, APPENDIX I
ENGINE
CRITICAL
ALTITUDE
RUNWAY ALTITUDE ~ FEET
0
2000
4000
6000
8000
10000
12000
400
600
800
1000
1200
700
900
1100
1300
1500
1700
GROUND DISTANCE ~ FEET
TOTAL DISTANCE TO 50 FEET ~ FEET

Figure No. 4
Take-off Summary
CV-2B S/N 62-4175
Dry Concrete Runway
Engine Model R-2000-7M2
Center of Gravity (Mid) C.G.
Standard Day +20°C
Take-off Power
STOL Technique

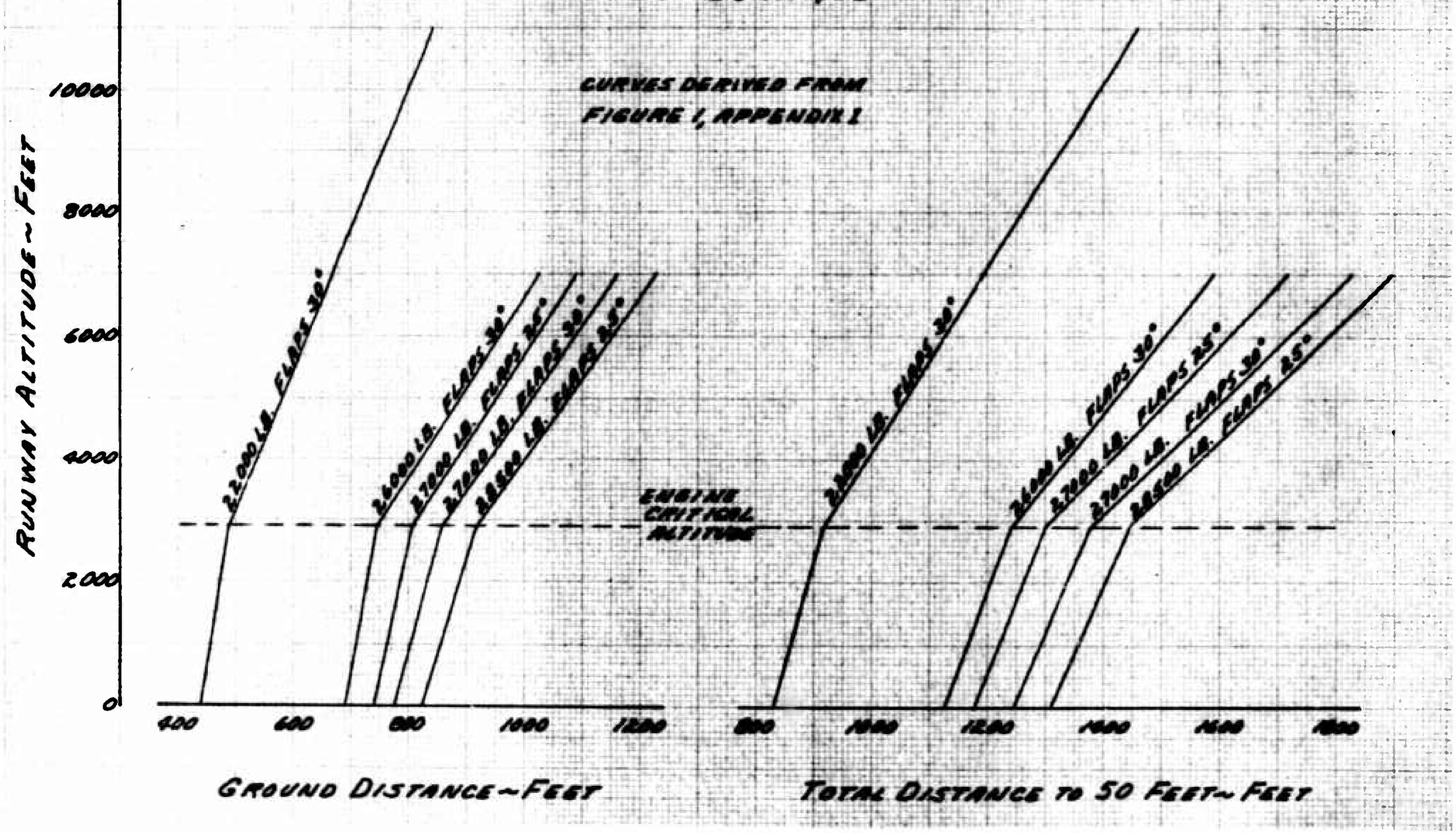


FIGURE No. 5

TAKE-OFF PERFORMANCE

CV-2B S/N 62-4175

DRY CONCRETE RUNWAY

ENGINE MODEL R-2000-7M2

30° FLAPS

GROSS WEIGHT = 22000 LB

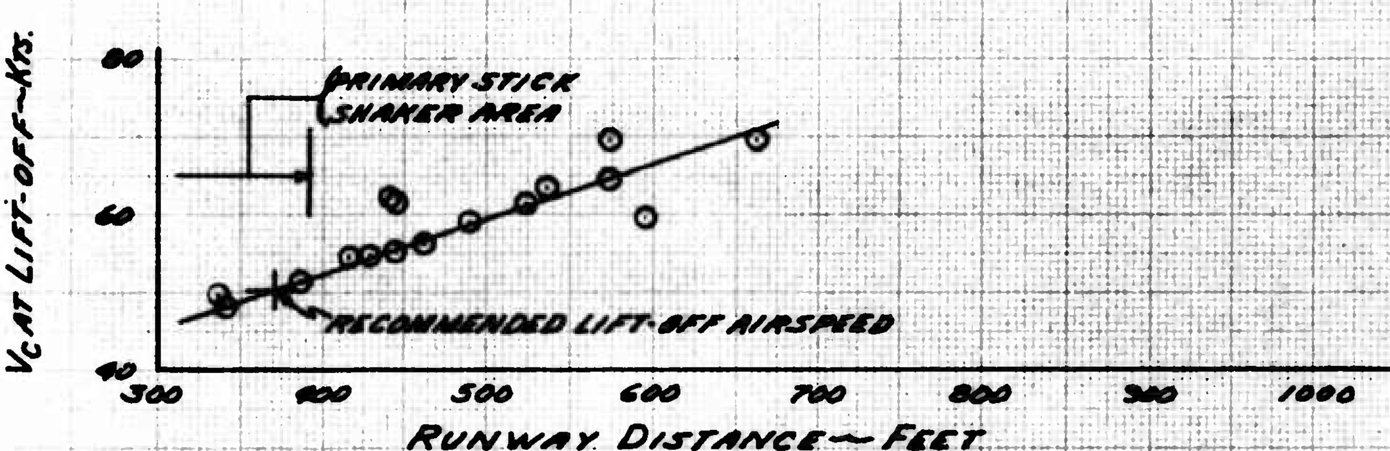
ALTITUDE = SEA LEVEL

+ DENOTES RECOMMENDED CAL. AIRSPEED FOR "SHORT FIELD" TECHNIQUE

IMMEDIATE FLAP RETRACTION TECHNIQUE

NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS

CENTER OF GRAVITY = 32.9% MAC (MID)



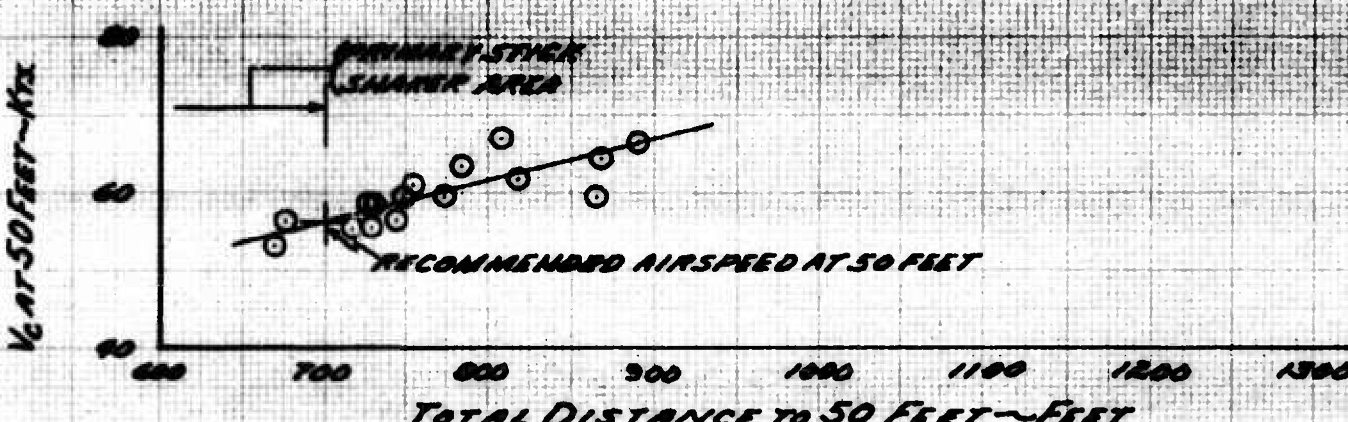
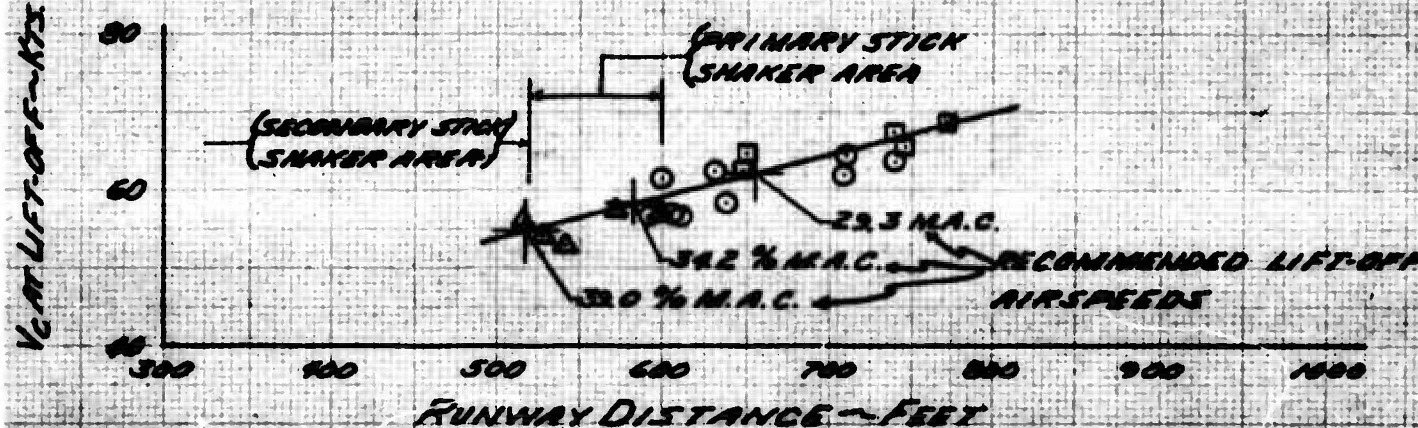



FIGURE NO. 6
TAKE-OFF PERFORMANCE
CV-2B S/N 62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
30° FLAPS
GROSS WEIGHT = 26000 LB.
ALTITUDE = SEA LEVEL

+ DENOTES RECOMMENDED CAL AIRSPEED FOR "SHORT FIELD" TECHNIQUE
IMMEDIATE FLAP RETRACTION TECHNIQUE

NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS

| SYMBOL | CENTER OF GRAVITY |
|---|---|
| □ | 23.3% M.A.C. (FWD) |
| ○ | 34.2% M.A.C. (MID) |
| △ | 39.0% M.A.C. (AFT) |



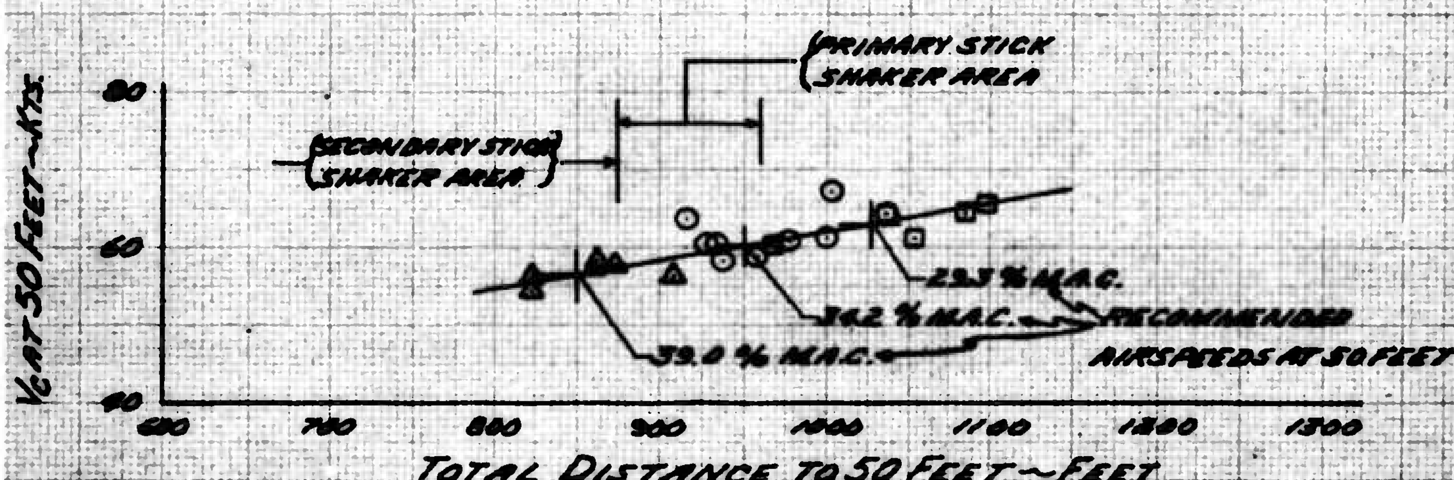
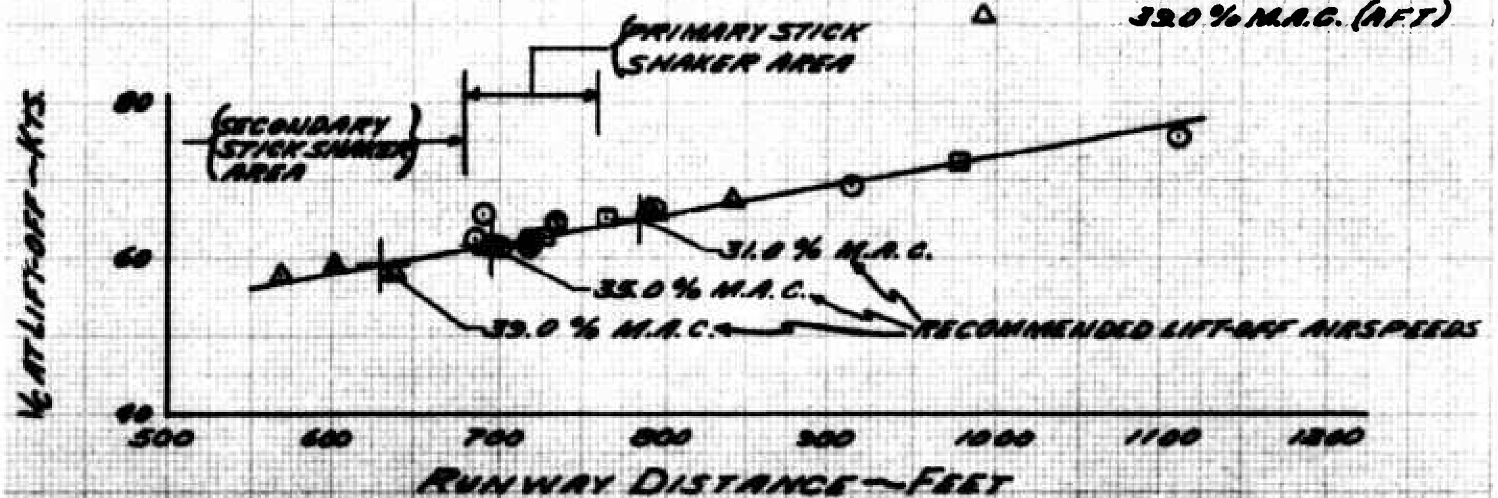



FIGURE NO. 7
TAKE-OFF PERFORMANCE
CV-2B S/N62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
25° FLAPS
GROSS WEIGHT=28500LB.
ALTITUDE=SEA LEVEL

+DENOTES RECOMMENDED CAL. AIRSPEED FOR "SHORT FIELD" TECHNIQUE
IMMEDIATE FLAP RETRACTION TECHNIQUE

NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS.

| SYMBOL | CENTER OF GRAVITY |
|---|---|
| □ | 31.0 % M.A.C. (FWD) |
| ○ | 35.0 % M.A.C. (MID) |
| △ | 39.0 % M.A.C. (AFT) |



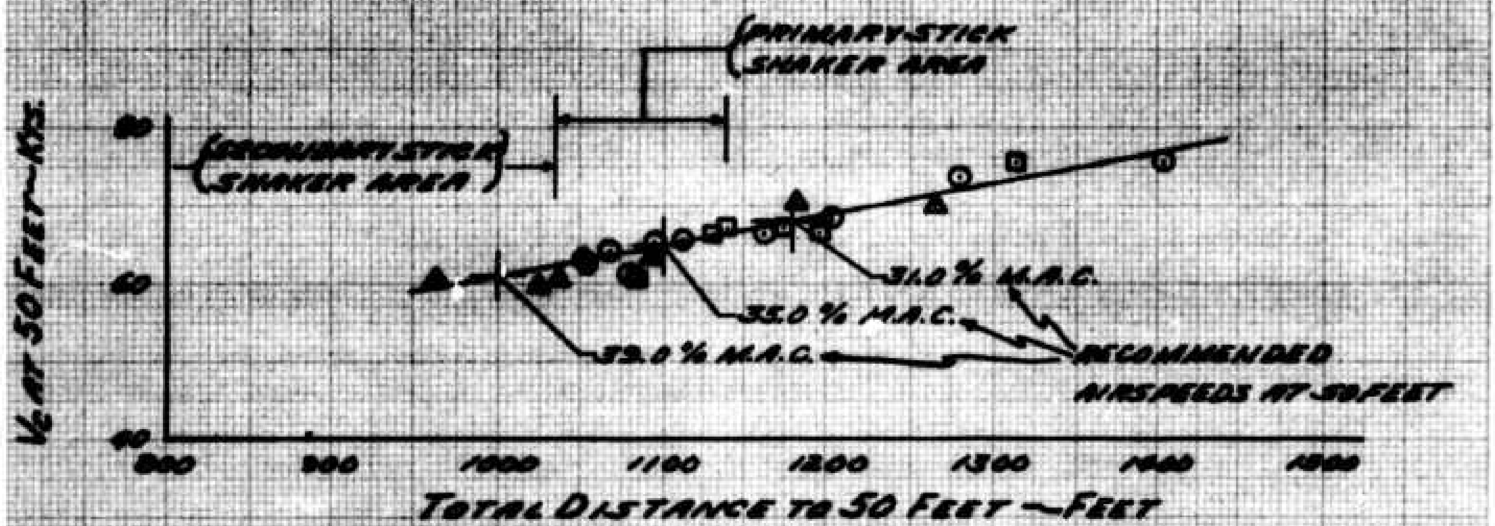
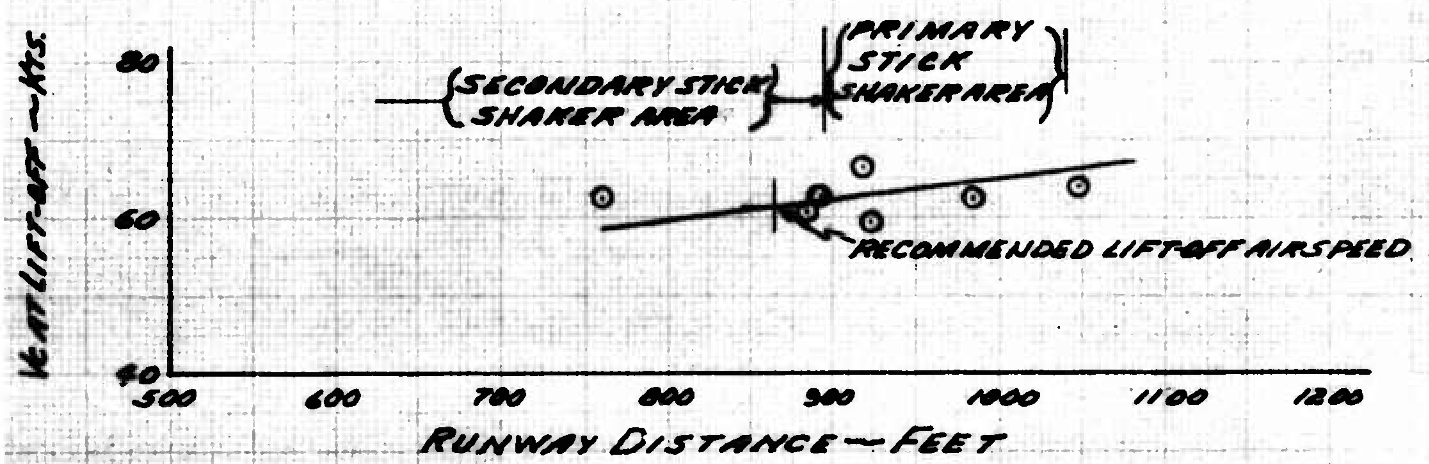



FIGURE NO. 8
TAKE-OFF PERFORMANCE
CV-2B S/N 62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
25° FLAPS
GROSS WEIGHT = 28500 LB.
ALTITUDE = 4000 FEET

+ DENOTES RECOMMENDED CAL. AIRSPEED FOR "SHORT FIELD" TECHNIQUE
IMMEDIATE FLAP RETRACTION TECHNIQUE

NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS.
CENTER OF GRAVITY = 35.0 % M.A.C. (MID)



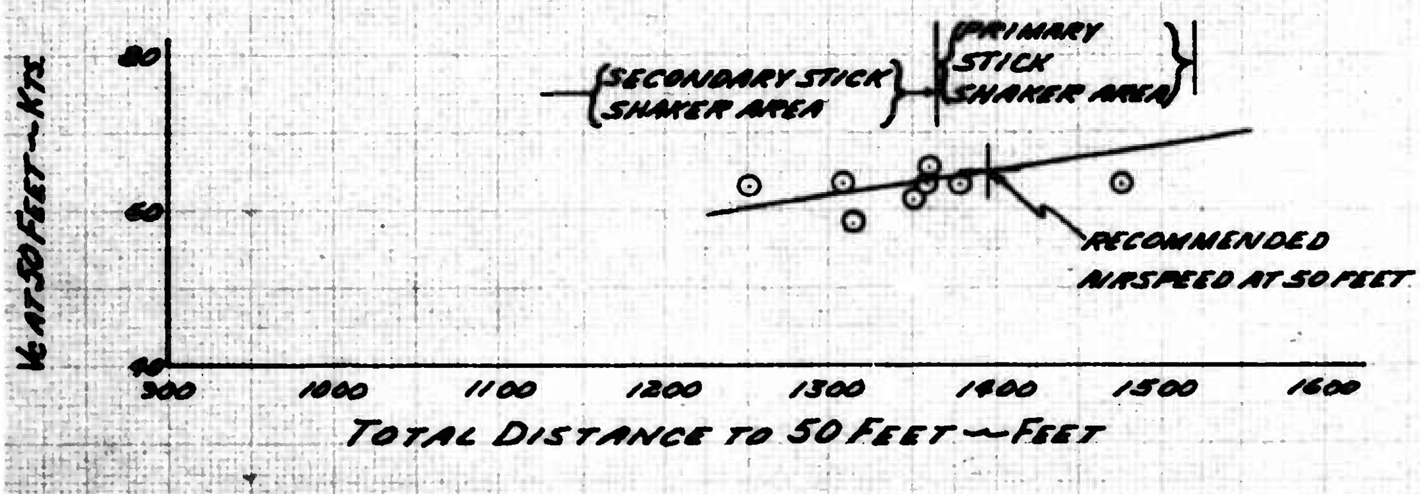



FIGURE No. 9

TAKE-OFF PERFORMANCE

CV-2B S/N62-4175

DRY CONCRETE RUNWAY

ENGINE MODEL R-2000-7M2

30° FLAPS

GROSS WEIGHT = 22000 LB.

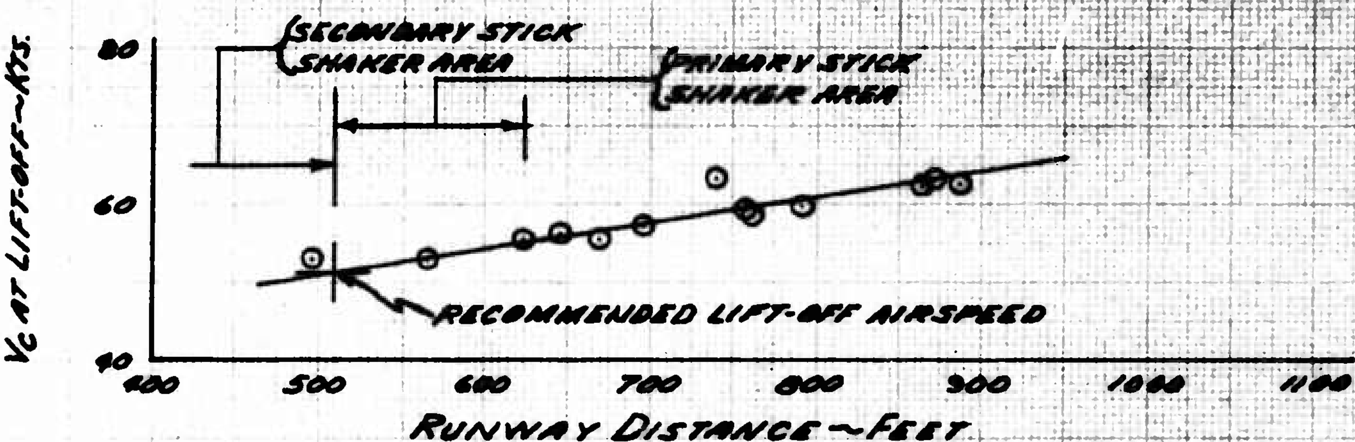
ALTITUDE = 6000 FEET

+ DENOTES RECOMMENDED CAL. AIRSPEED FOR "SHORT FIELD" TECHNIQUE

IMMEDIATE FLAP RETRACTION TECHNIQUE

NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS.

CENTER OF GRAVITY = 32.9 % M.A.C. (MID)



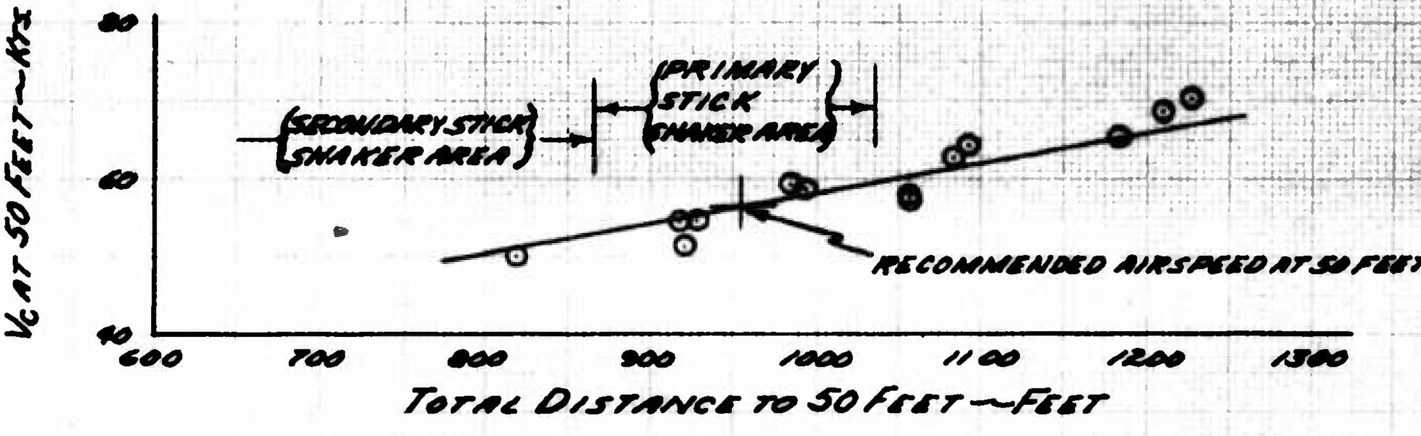
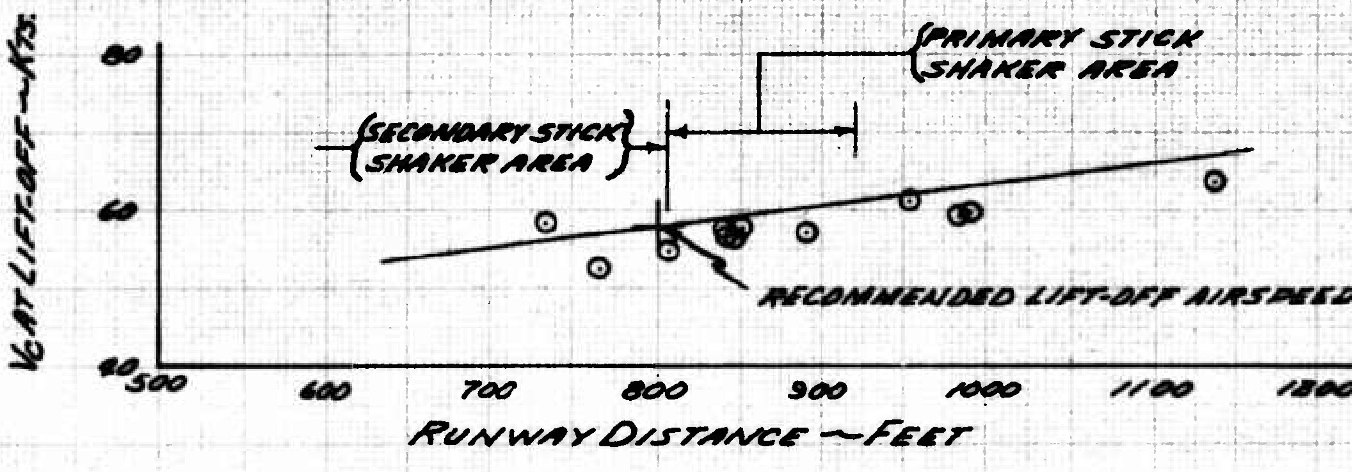



FIGURE No. 10
TAKE-OFF PERFORMANCE
CV-2B S/N 62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
30° FLAPS
GROSS WEIGHT - 26000 LB.
ALTITUDE - 6000 FEET

+ DENOTES RECOMMENDED CAL. AIRSPEED FOR "SHORT FIELD" TECHNIQUE
IMMEDIATE FLAP RETRACTION TECHNIQUE

NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS
CENTER OF GRAVITY - 34.2 % M.A.C. (MID)



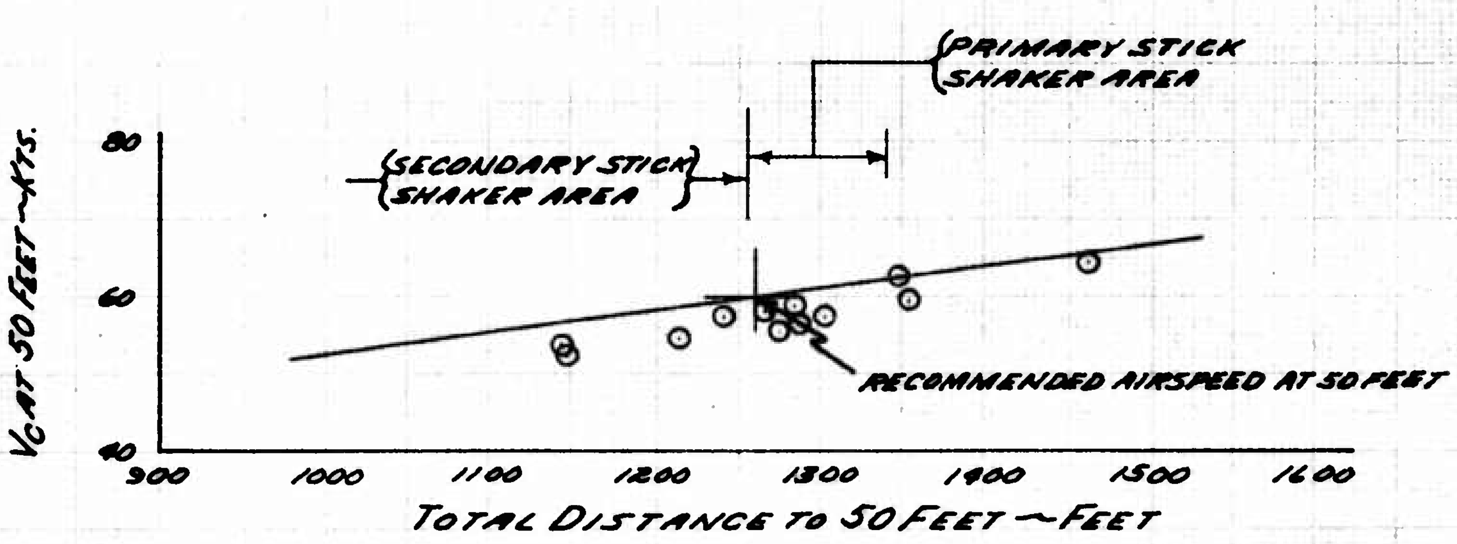



FIGURE No 11
TAKE-OFF PERFORMANCE
CV-2B S/N 62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
30° FLAPS
GROSS WEIGHT - 27000 LB.
ALTITUDE: 6000 FEET

+ DENOTES RECOMMENDED ROLL AIRSPEED FOR "SHORT FIELD" TECHNIQUE
DELAYED FLAP RETRACTION TECHNIQUE

NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS.
CENTER OF GRAVITY: 34.5 % M.A.C. [illegible]

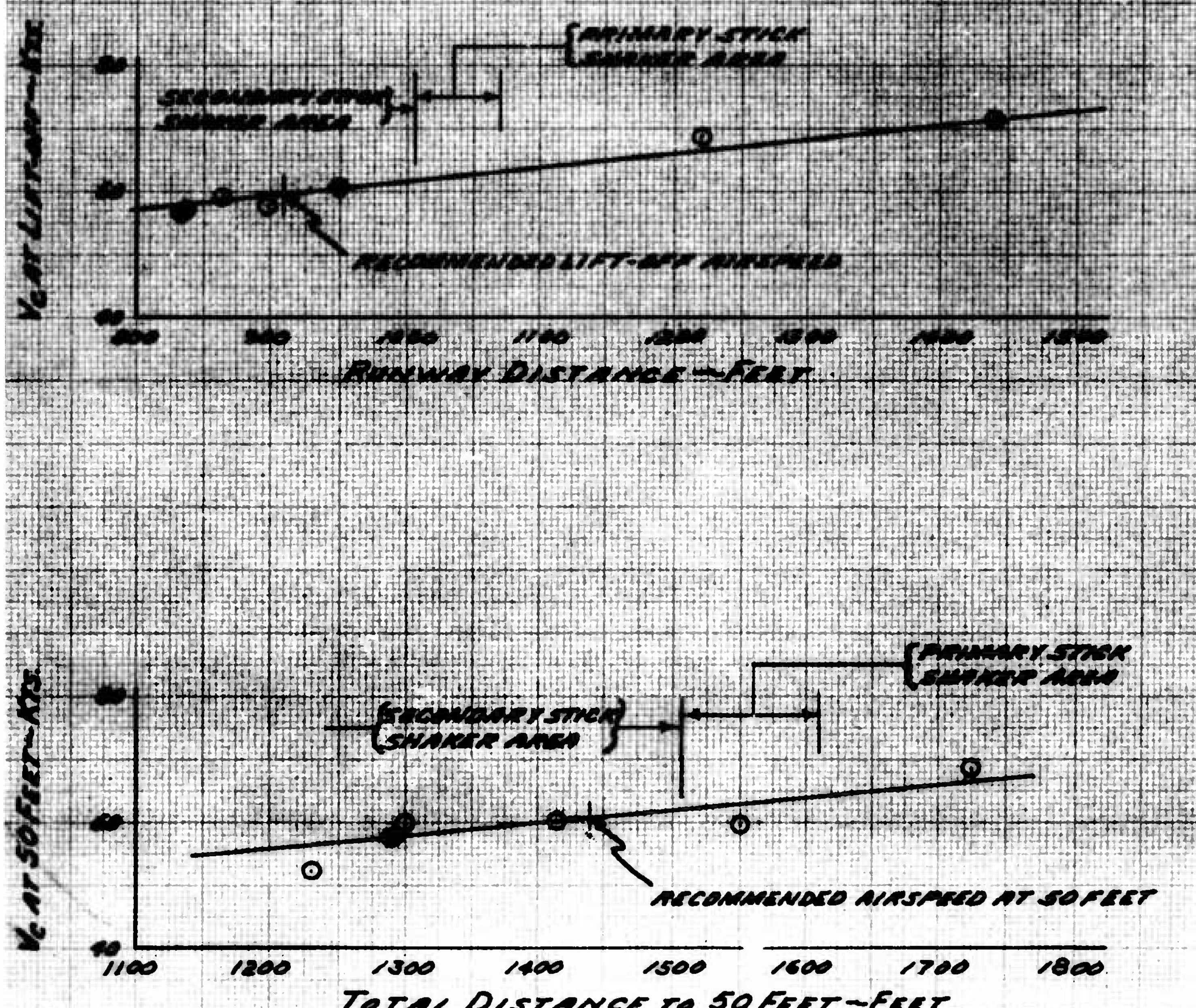
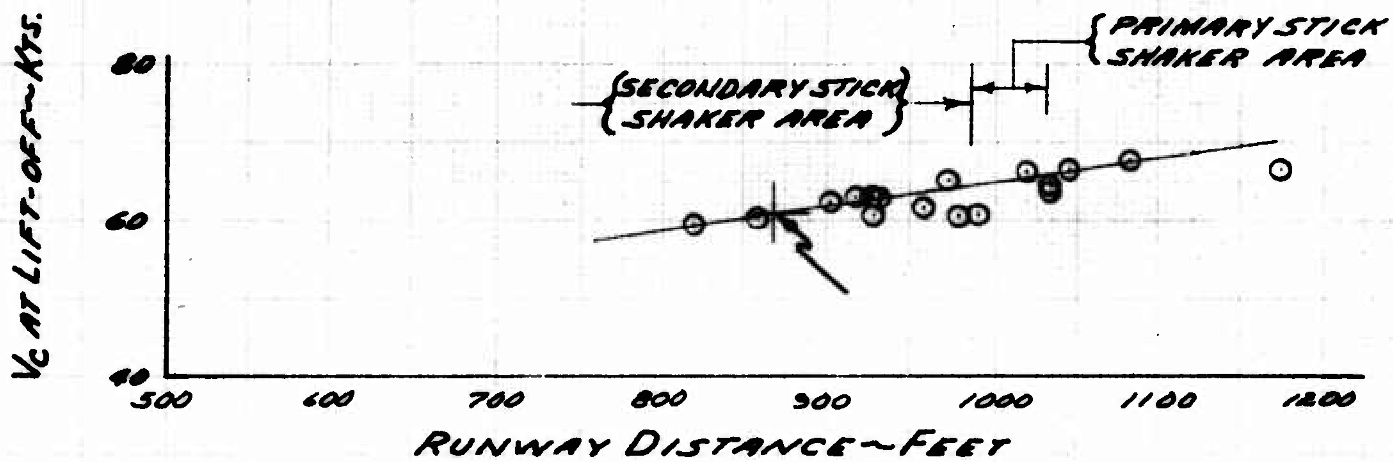


FIGURE NO. 12
TAKE-OFF PERFORMANCE
CV-2B S/N 62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
25° FLAPS
GROSS WEIGHT • 27000 LB.
ALTITUDE • 6000 FEET

+ DENOTES RECOMMENDED CAL. AIRSPEED FOR "SHORT FIELD" TECHNIQUE
DELAYED FLAP RETRACTION TECHNIQUE

NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS.
CENTER OF GRAVITY • 34.5 % M.A.C. (MID)



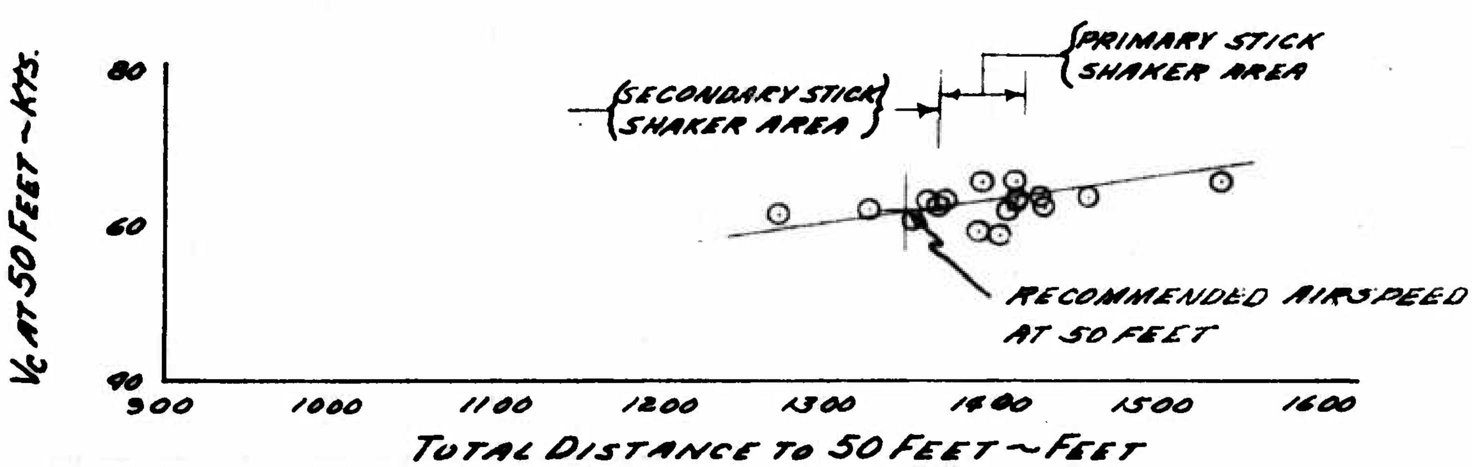
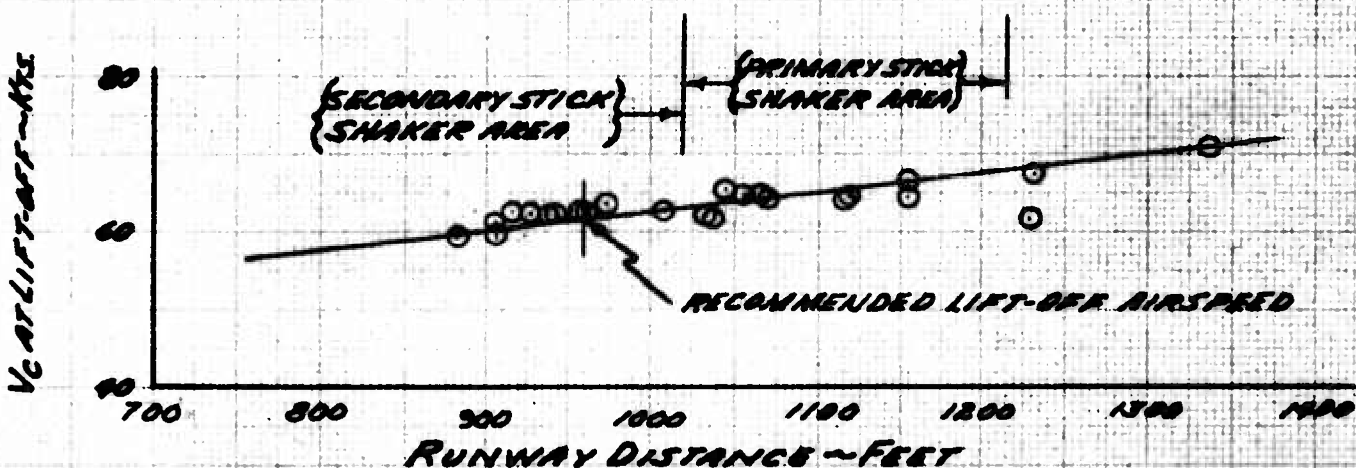



FIGURE No. 13
TAKE-OFF PERFORMANCE
CV-2B S/N 62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
25° FLAPS
GROSS WEIGHT = 28500 LB.
ALTITUDE = 6000 FEET

+ DENOTES RECOMMENDED CAL. AIRSPEED FOR "SHORT FIELD" TECHNIQUE
DELAYED FLAP RETRACTION TECHNIQUE

NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS.
CENTER OF GRAVITY = 35.0 % M.A.C. (MID)



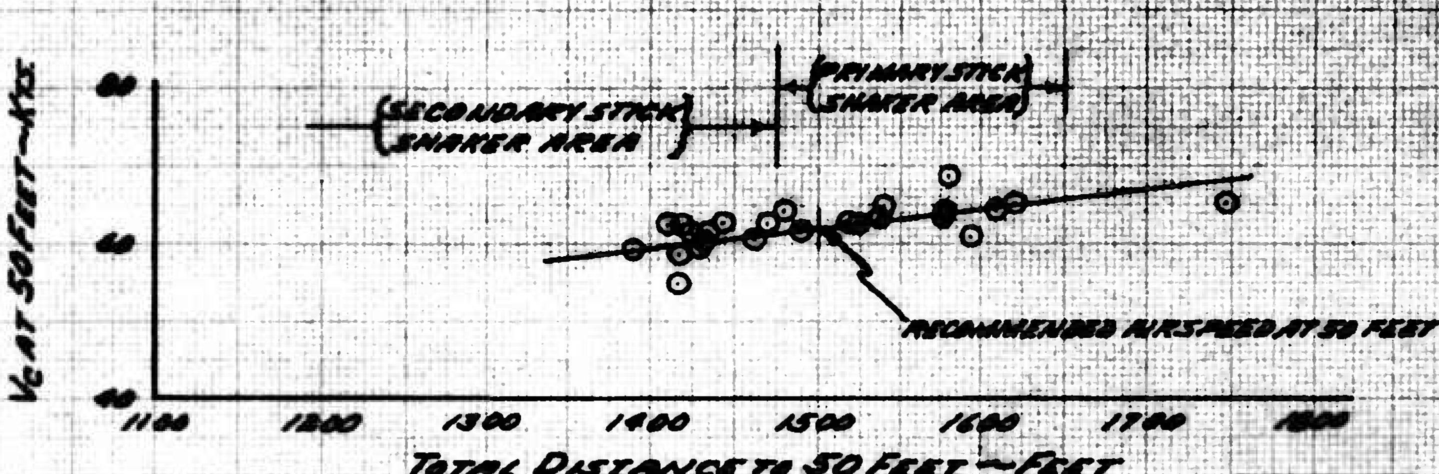



FIGURE NO. 14

TAKE-OFF PERFORMANCE

CV-2B S/N 62-4175

DRY SOD RUNWAY

ENGINE MODEL R-2000-7M2

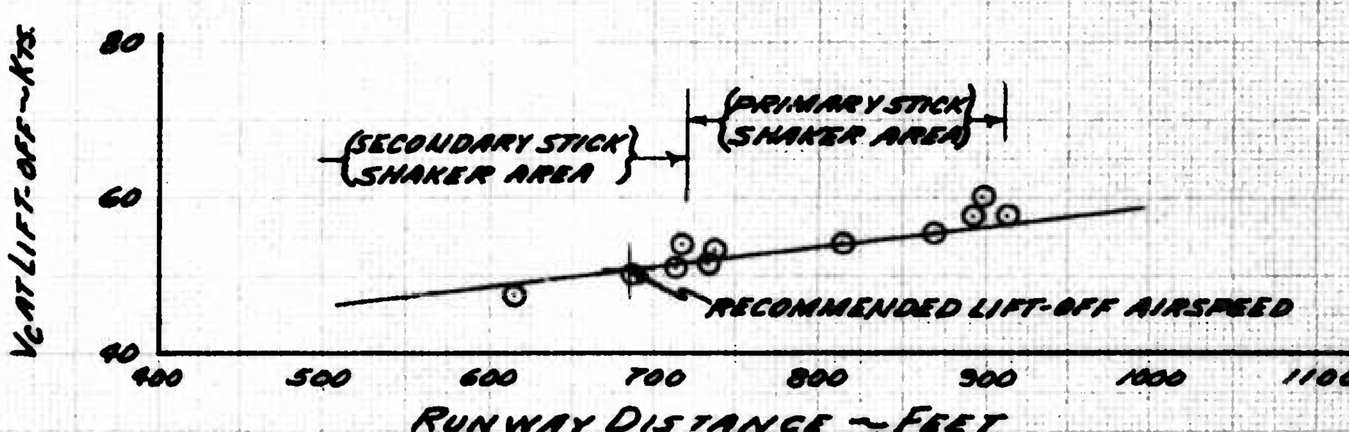
30° FLAPS

GROSS WEIGHT = 22000 LB.

ALTITUDE = 10000 FEET

+ DENOTES RECOMMENDED CAL. AIRSPEED FOR "SHORT FIELD" TECHNIQUE
PARTIAL FLAP RETRACTION TECHNIQUE

NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS.
CENTER OF GRAVITY: 32.9 % M.A.C. (MID)



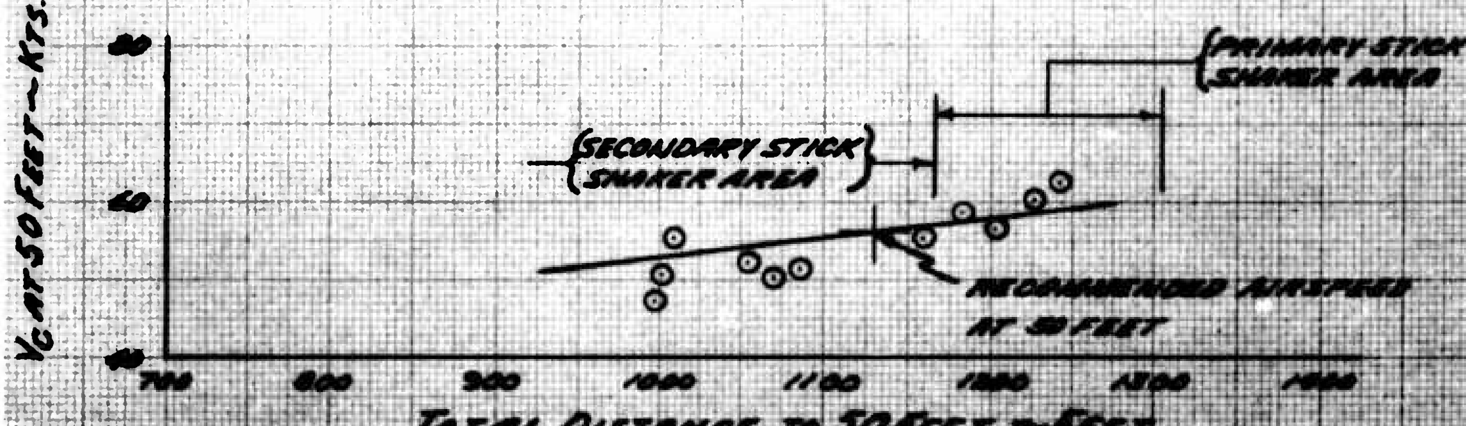



FIGURE NO. 15
CALIBRATED AIRSPEED VS INDICATED AIRSPEED
DURING TAKE-OFF AND LANDING
CV-2B S/N 62-4175
ENGINE MODEL R-2000-7M2
STANDARD AIRSPEED SYSTEM

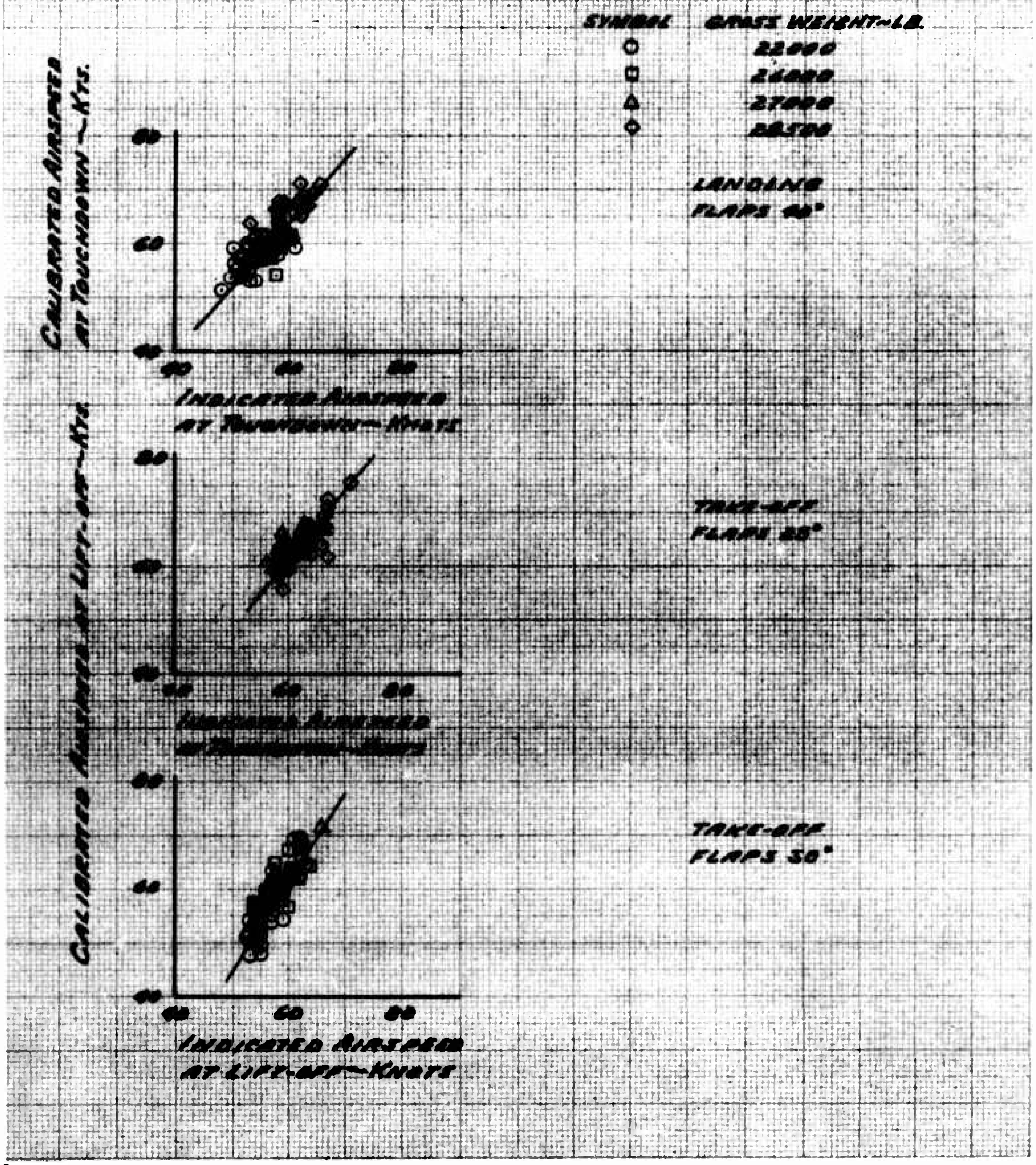


FIGURE NO. 16

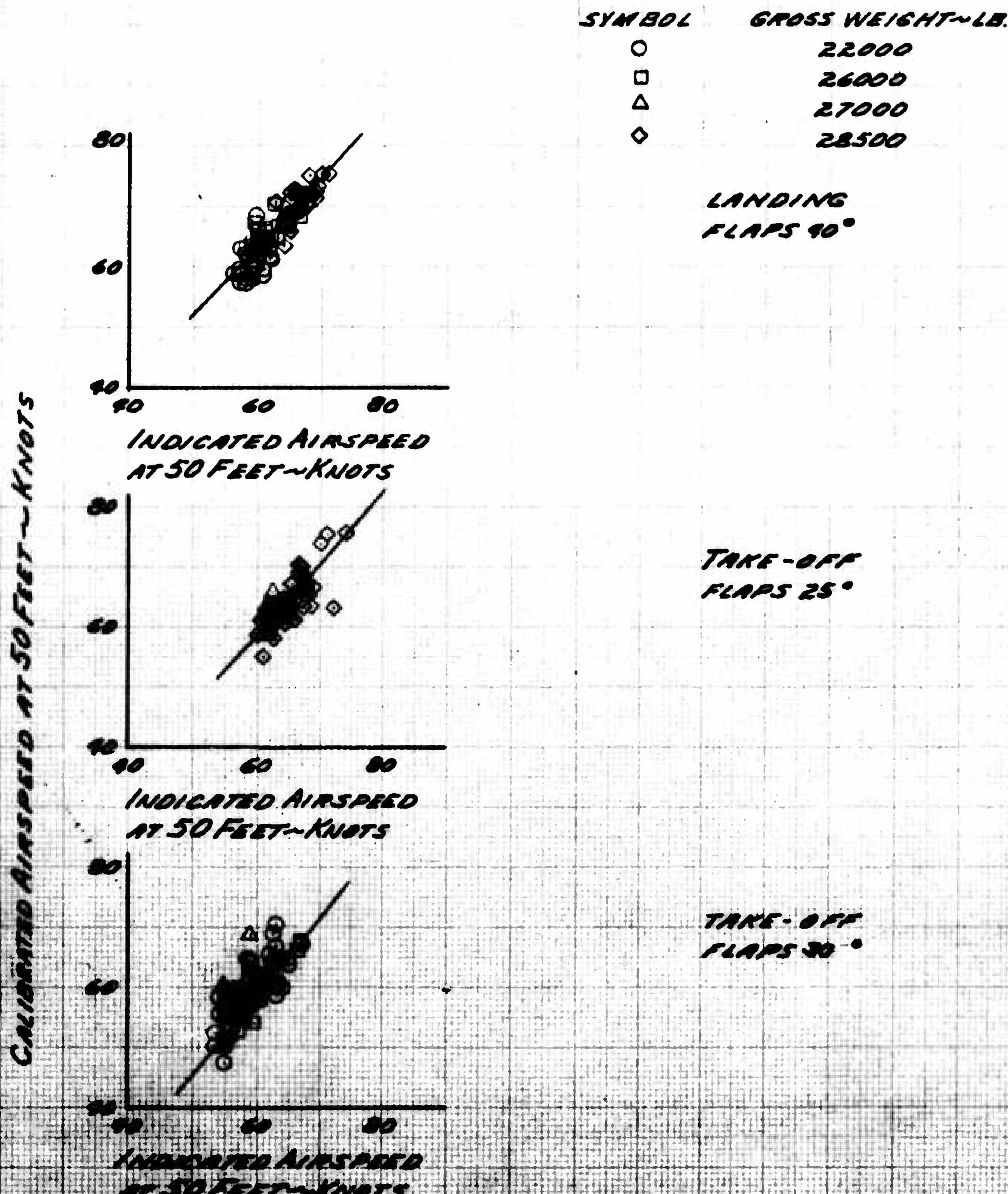
CALIBRATED AIRSPEED VS INDICATED AIRSPEED

DURING TAKE-OFF AND LANDING

CV-2B S/N 62-4175

ENGINE MODEL R-2000-7M2

STANDARD AIRSPEED SYSTEM



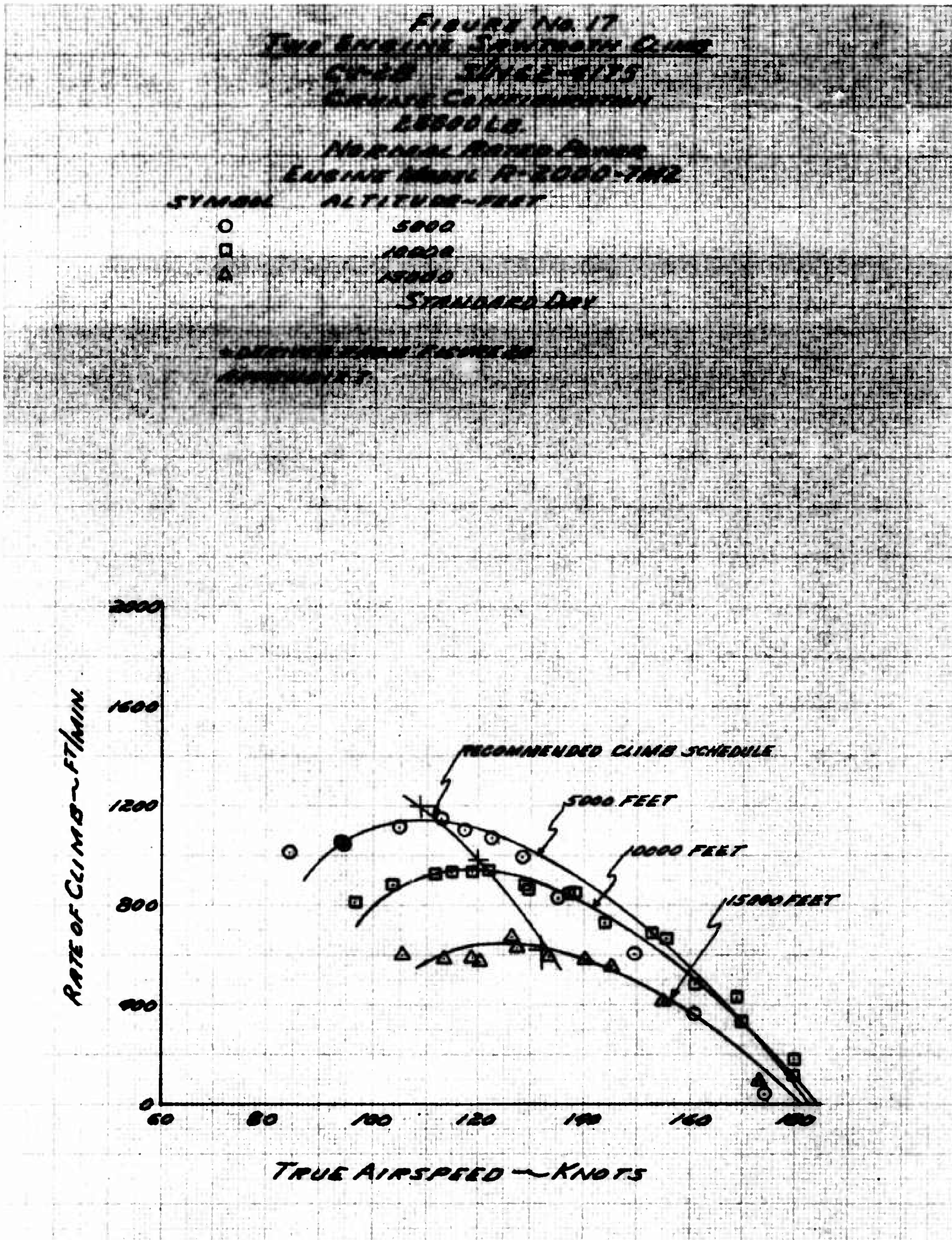


FIGURE No. 17
TWO ENGINE SAWTOOTH CLIMB
NORMAL RATED POWER
SYMBOL ALTITUDE~FEET
5000
10000
15000
STANDARD DAY
RECOMMENDED CLIMB SCHEDULE
5000 FEET
10000 FEET
15000 FEET
RATE OF CLIMB ~ FT/MIN
0
400
800
1200
1600
2000
60
80
100
120
140
160
180
TRUE AIRSPEED ~ KNOTS

FIGURE NO. 18
TWO ENGINE SAWTOOTH CLIMBS
CV-2B S/N 62-4175
CRUISE CONFIGURATION
31300 LB
NORMAL RATED POWER
ENGINE MODEL R-2000-7M2

| SYMBOL | ALTITUDE ~ FEET |
|---|---|
| □ | 7000 |
| | STANDARD DAY |

+ DERIVED FROM FIGURE 21, APPENDIX I

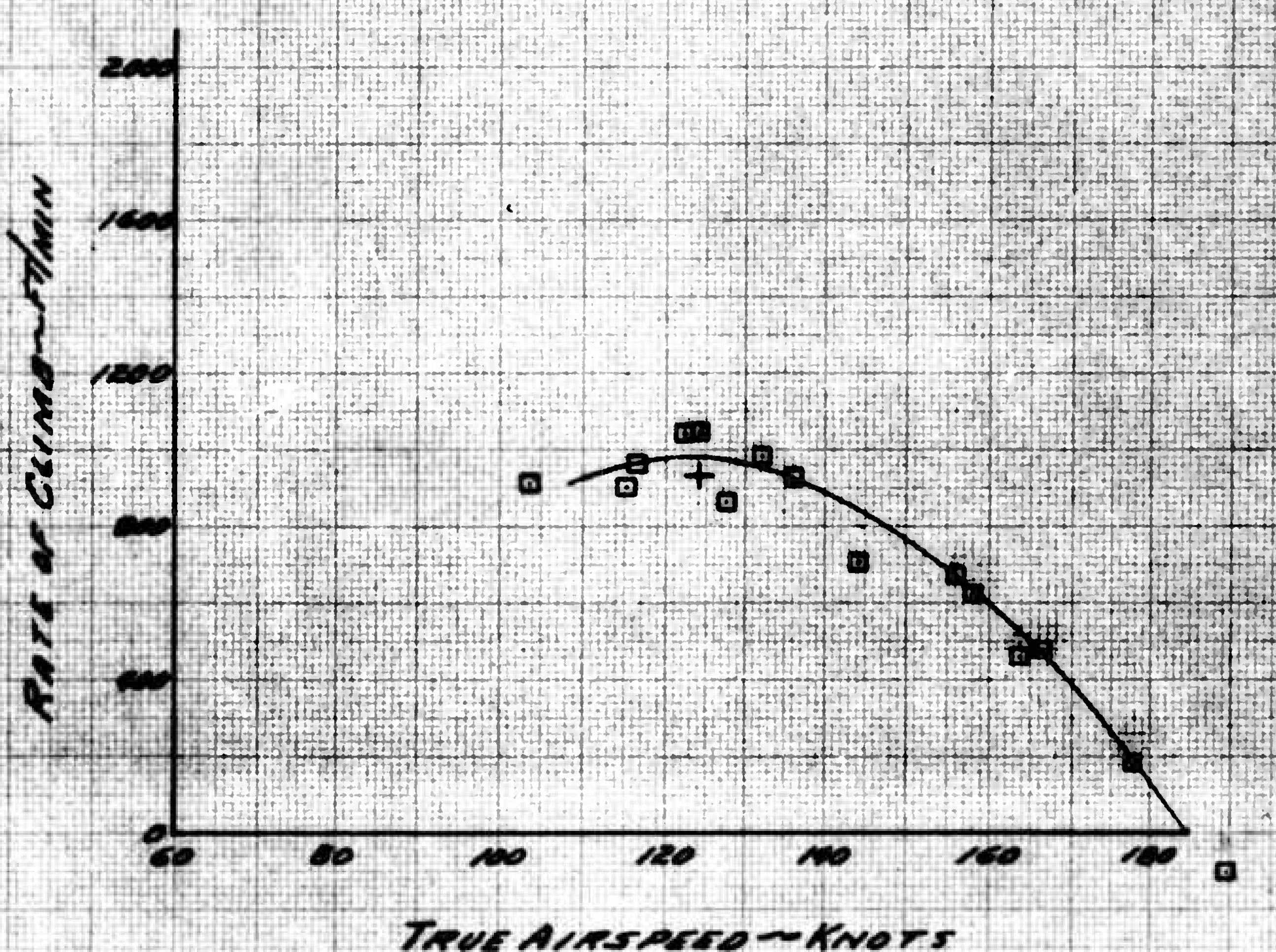


FIGURE NO. 19
TWO ENGINE CLIMB PERFORMANCE
CV-2B S/N 62-4175
NORMAL RATED POWER
22000 LB. AT SEA LEVEL
ENGINE MODEL R-2000-7M2
CLEAN CONFIGURATION
STANDARD DAY

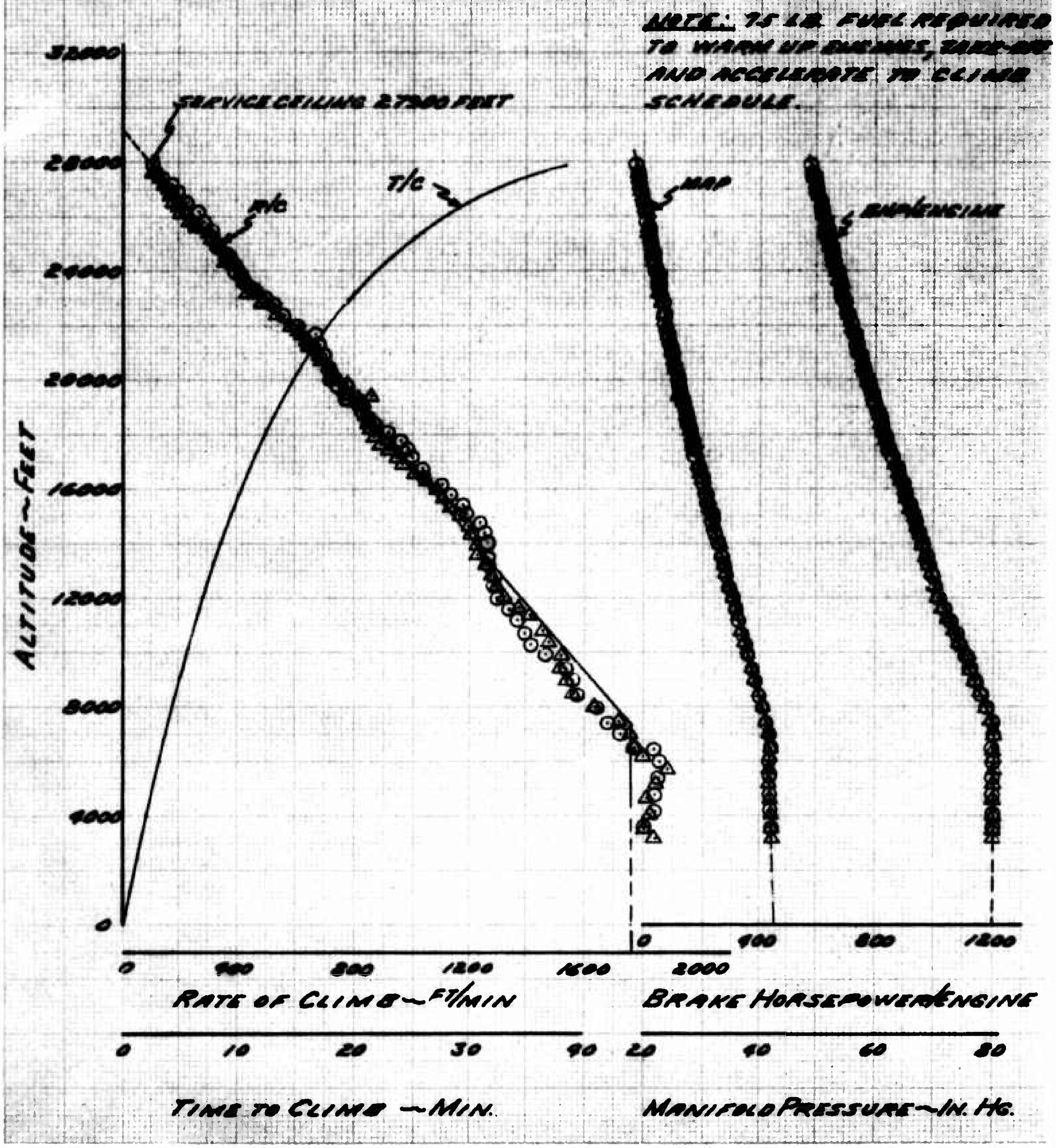


FIGURE NO. 13 (CON'T)

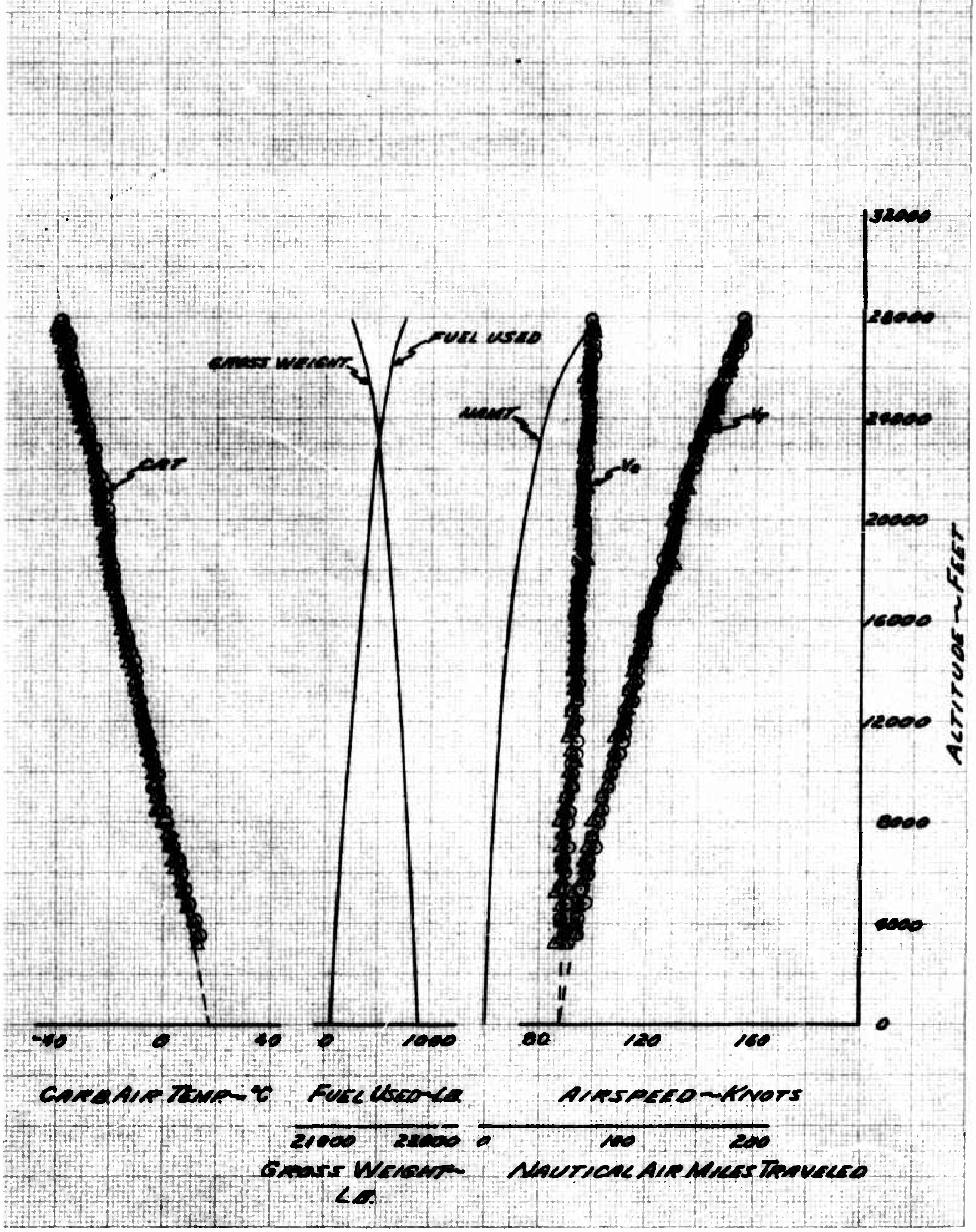


FIGURE No. 20
TWO ENGINE CLIMB PERFORMANCE
CV-2B S/N62-4175
NORMAL RATED POWER
28500 LB. AT SEA LEVEL
ENGINE MODEL R-2000-7M2
CLEAN CONFIGURATION
STANDARD DAY

+ DERIVED FROM FIGURE 17, APPENDIX

NOTE: 75 LB. FUEL REQUIRED TO WARM UP ENGINES, TAKE-OFF AND ACCELERATE TO CLIMB SCHEDULE.

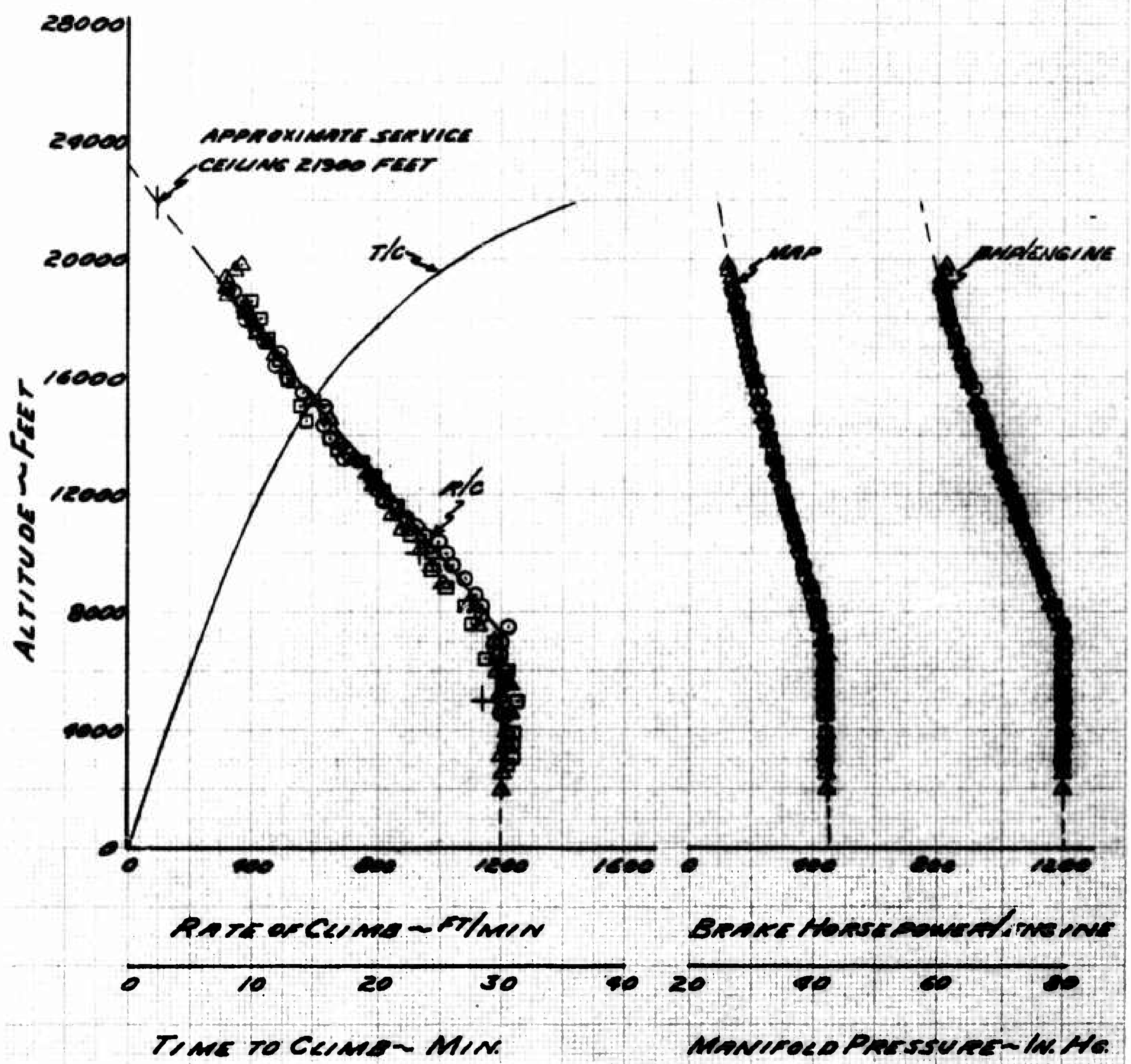


FIGURE No20 (CON'T)

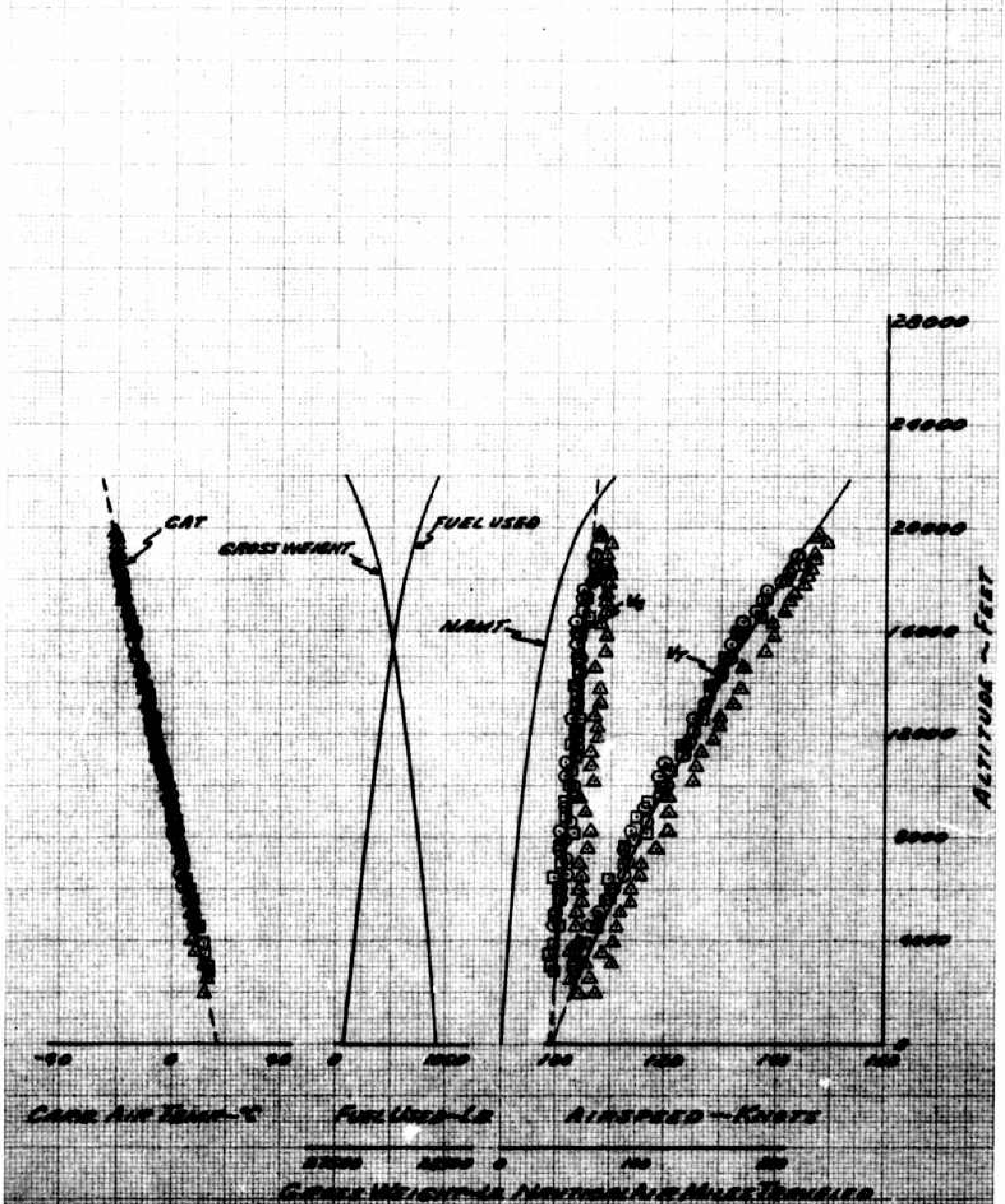


FIGURE NO. 21

TWO ENGINE CLIMB PERFORMANCE

CV-2B S/N 62-4175

NORMAL RATED POWER

31300 LB. AT SEA LEVEL

ENGINE MODEL R-2000-7M2

CLEAN CONFIGURATION

STANDARD DAY

+ DERIVED FROM FIGURE 18, APPENDIX I

NOTE: 75 LB. FUEL REQUIRED TO WARM UP ENGINES, TAKE-OFF AND ACCELERATE TO CLIMB SCHEDULE.

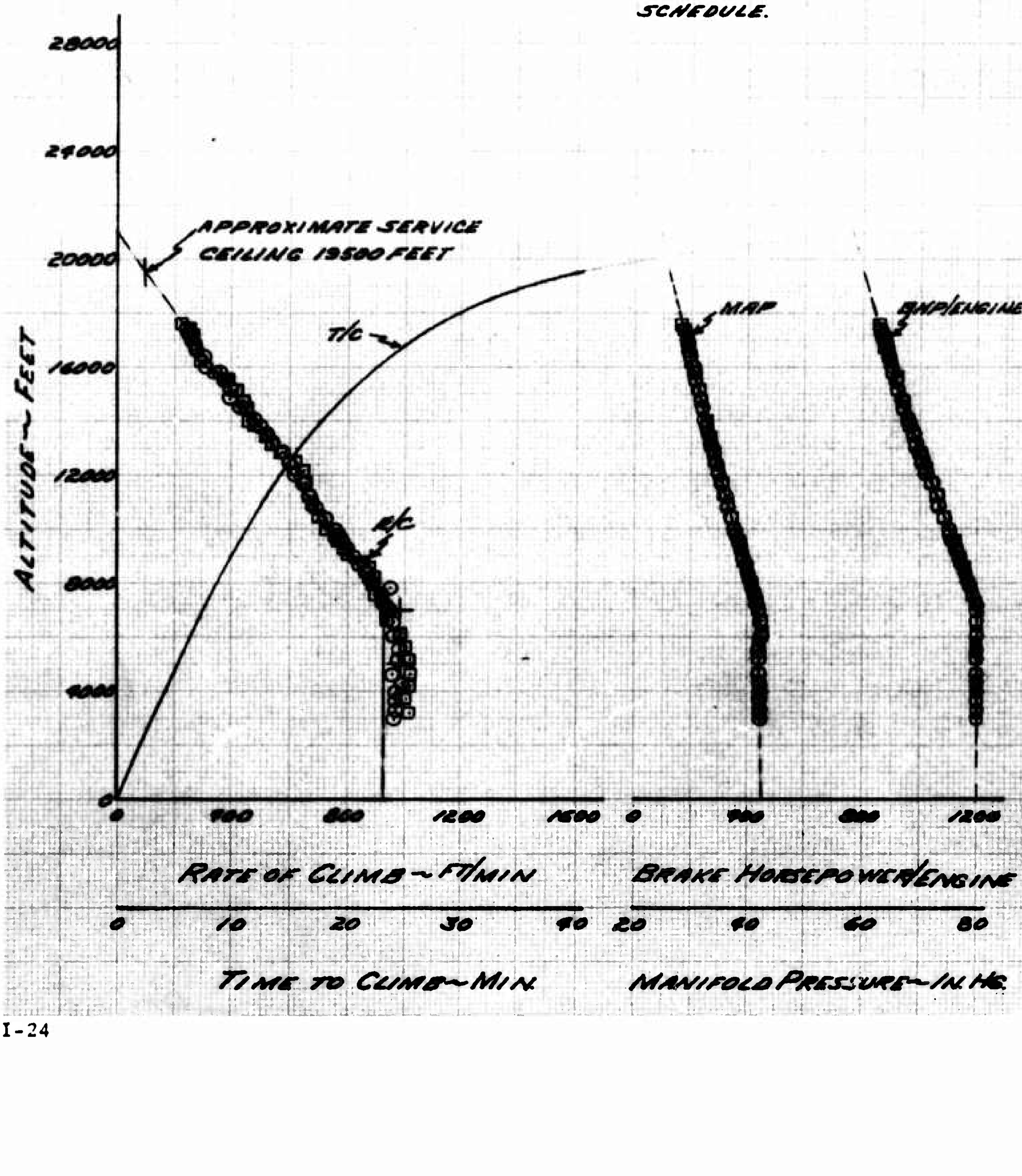
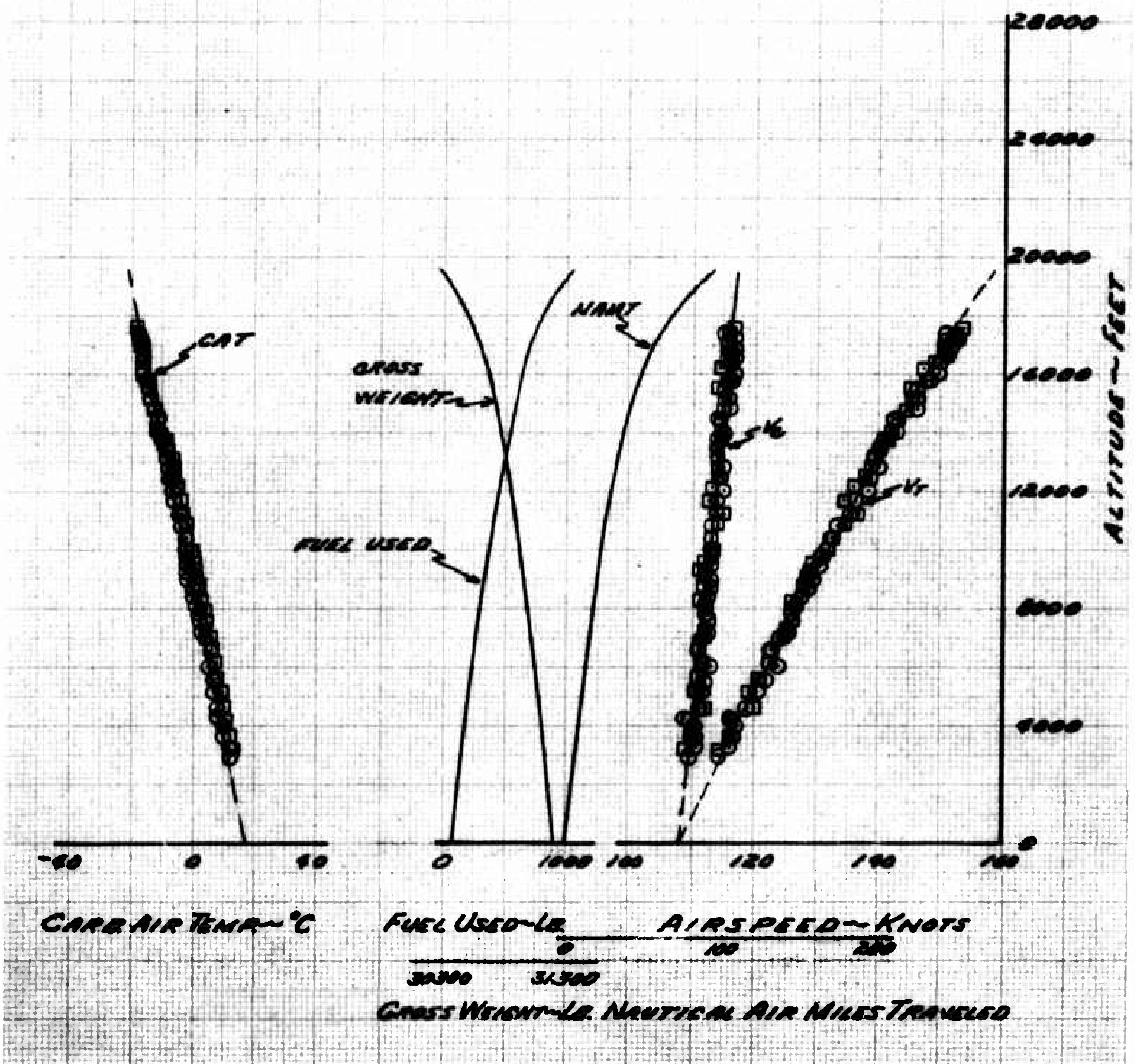


FIGURE No21 (CON'T)



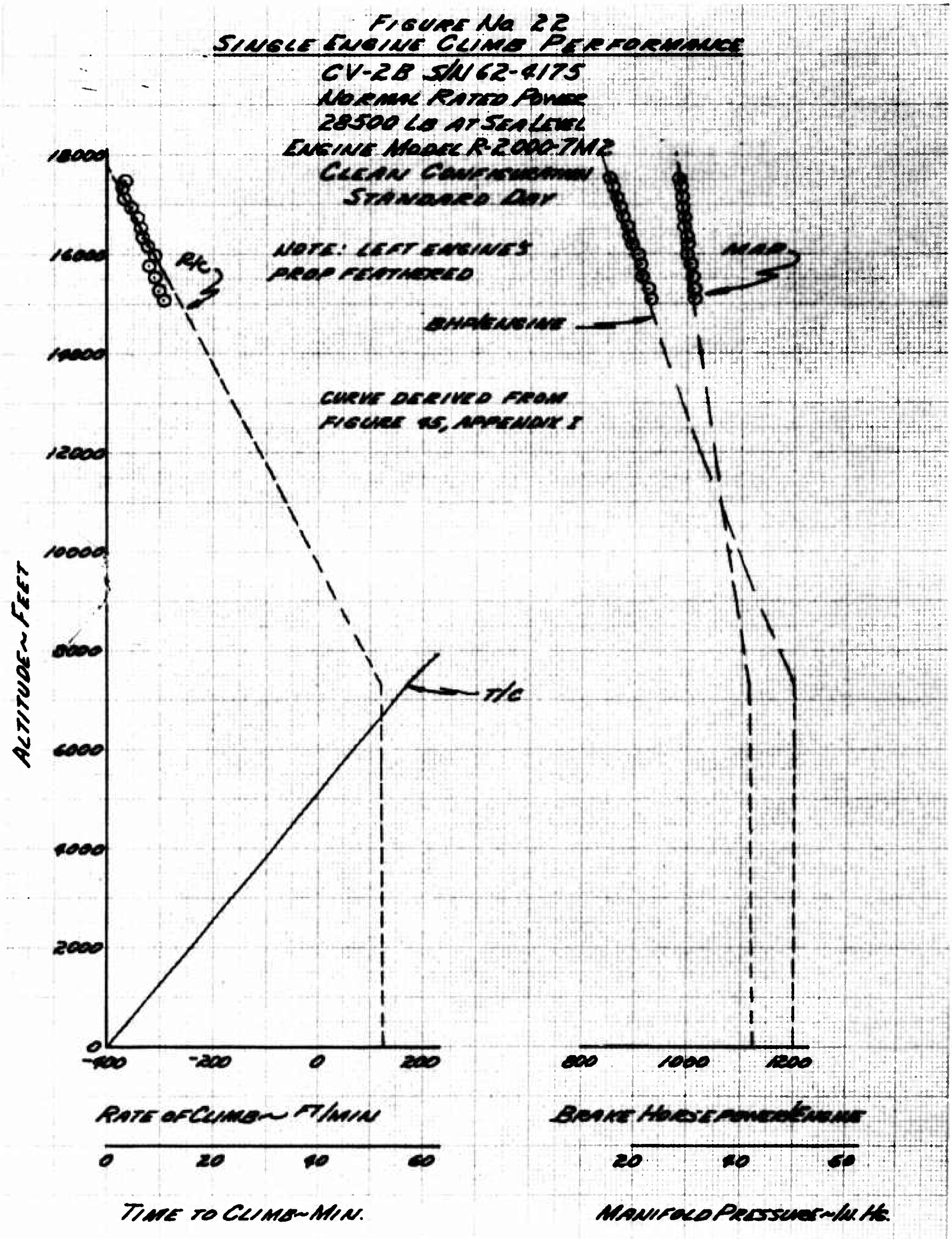
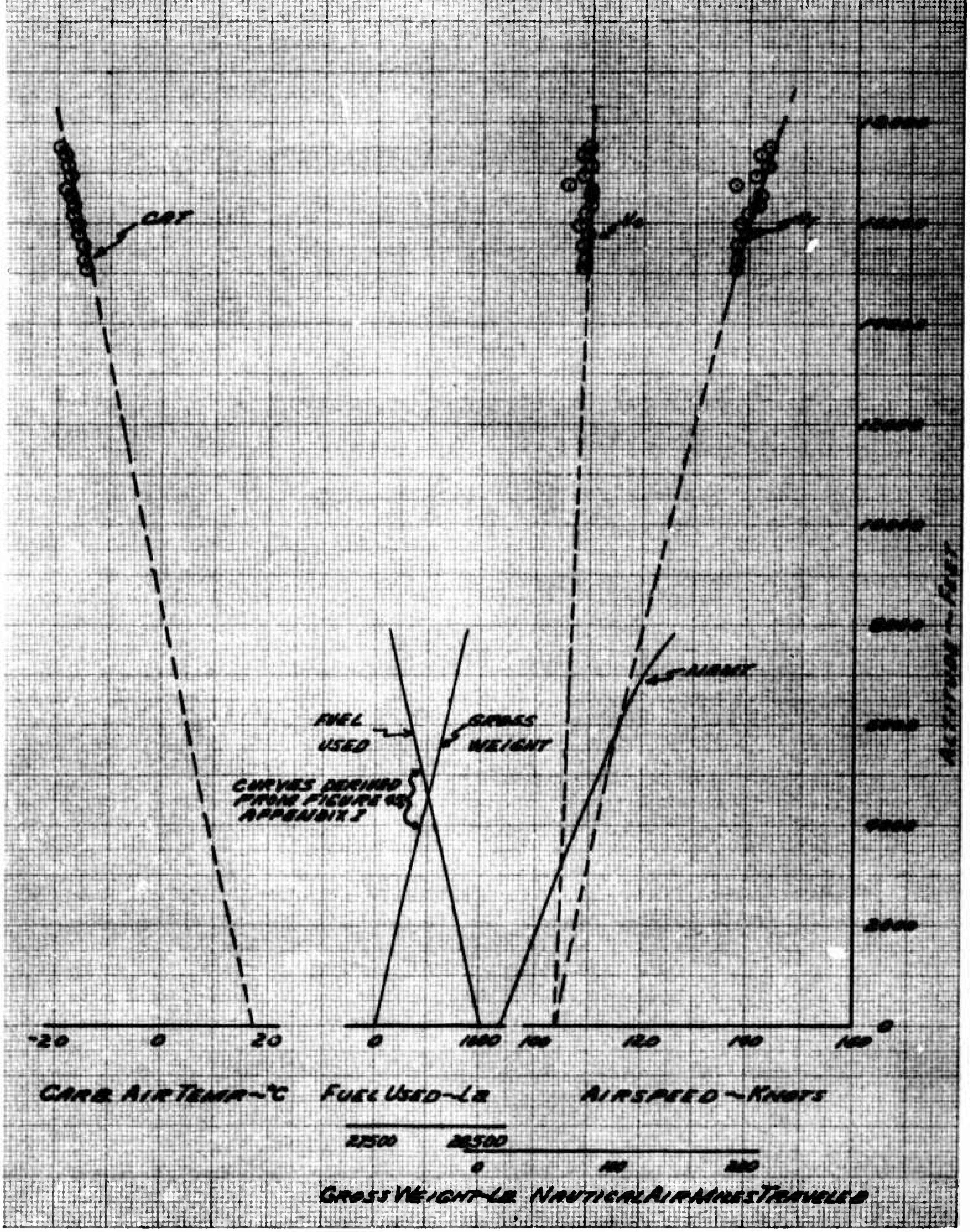


FIGURE No. 22
SINGLE ENGINE CLIMB PERFORMANCE
CV-2B S/N 62-4175
NORMAL RATED POWER
28500 LB AT SEA LEVEL
ENGINE MODEL R-2000-7M2
CLEAN CONFIGURATION
STANDARD DAY
NOTE: LEFT ENGINES PROP FEATHERED
CURVE DERIVED FROM FIGURE 45, APPENDIX I
R/C
T/C
MAP
BHP/ENGINE
ALTITUDE ~ FEET
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-400
-200
0
200
RATE OF CLIMB ~ FT/MIN
0
20
40
60
TIME TO CLIMB ~ MIN.
800
1000
1200
BRAKE HORSEPOWER/ENGINE
20
40
60
MANIFOLD PRESSURE ~ IN. HG.

FIGURE No.22 (CON'T)



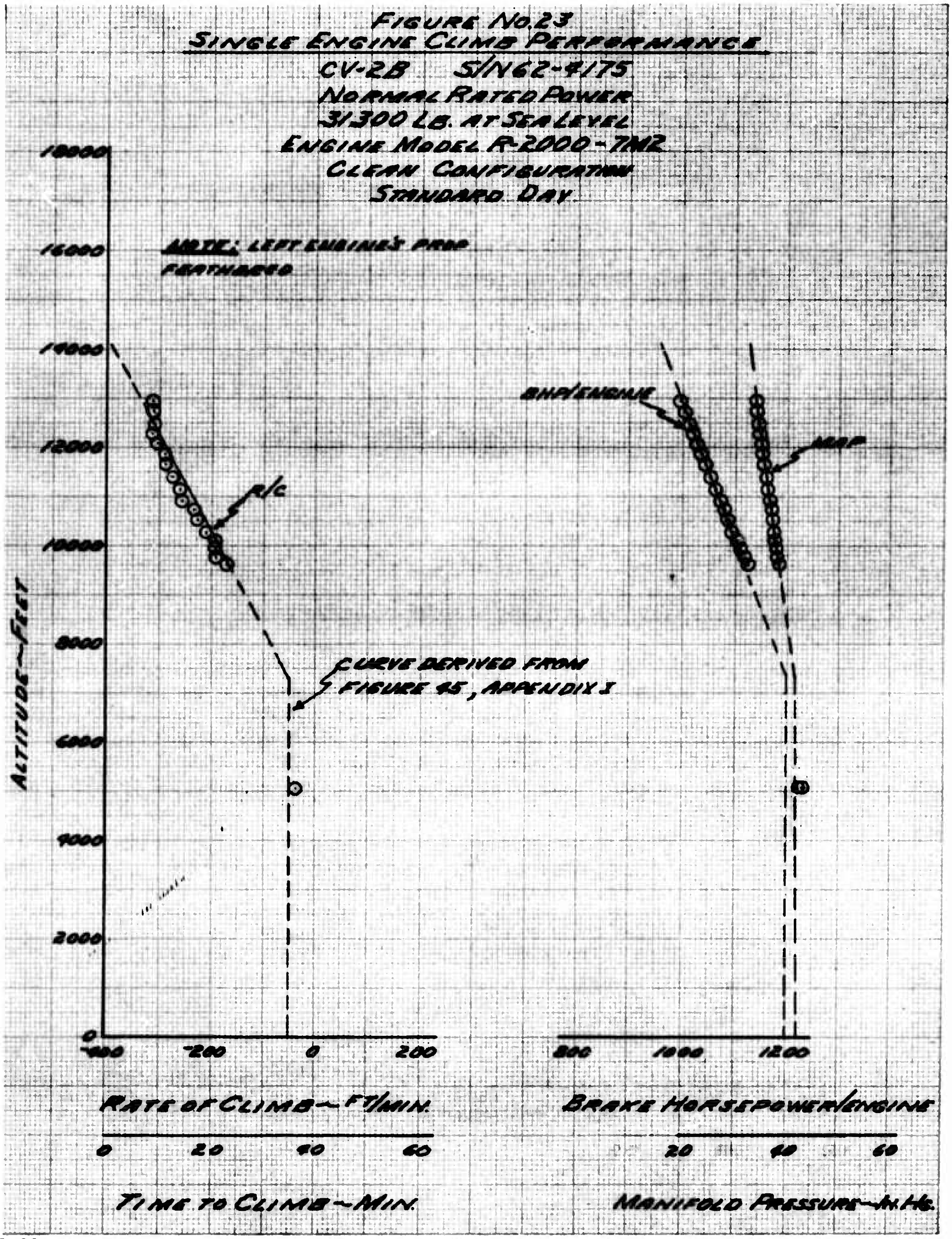


FIGURE NO. 23
SINGLE ENGINE CLIMB PERFORMANCE
CV-2B S/N 62-4175
NORMAL RATED POWER
31300 LB. AT SEA LEVEL
ENGINE MODEL R-2000-7M2
CLEAN CONFIGURATION
STANDARD DAY
NOTE: LEFT ENGINE'S PROP FEATHERED
BHP/ENGINE
MAP
R/C
CURVE DERIVED FROM FIGURE 45, APPENDIX I
ALTITUDE ~ FEET
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-400
-200
0
200
800
1000
1200
RATE OF CLIMB ~ FT/MIN.
BRAKE HORSEPOWER/ENGINE
0
20
40
60
20
40
60
TIME TO CLIMB ~ MIN.
MANIFOLD PRESSURE ~ IN. HG.

FIGURE NO. 23 (CON'T)

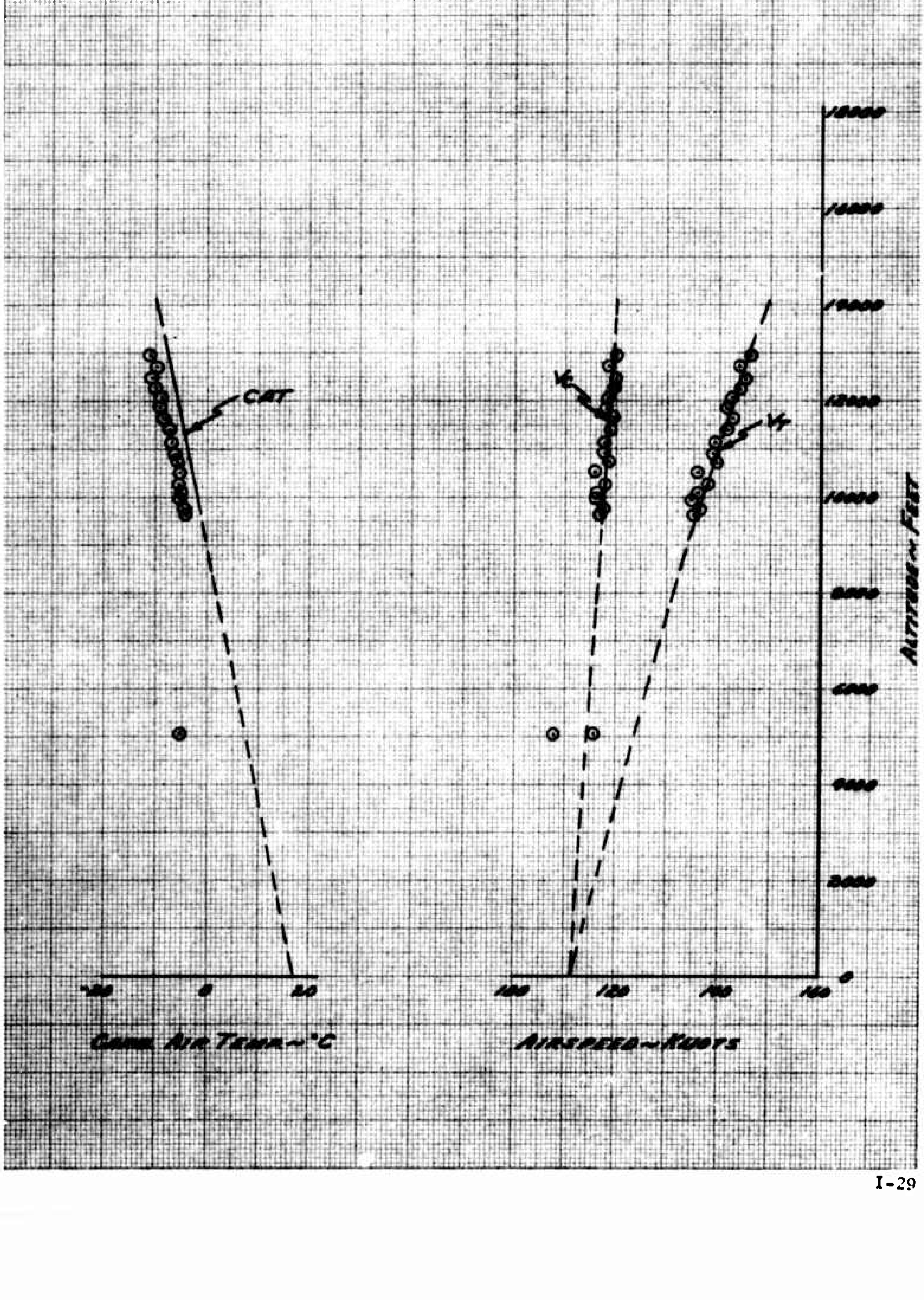


FIGURE No. 24

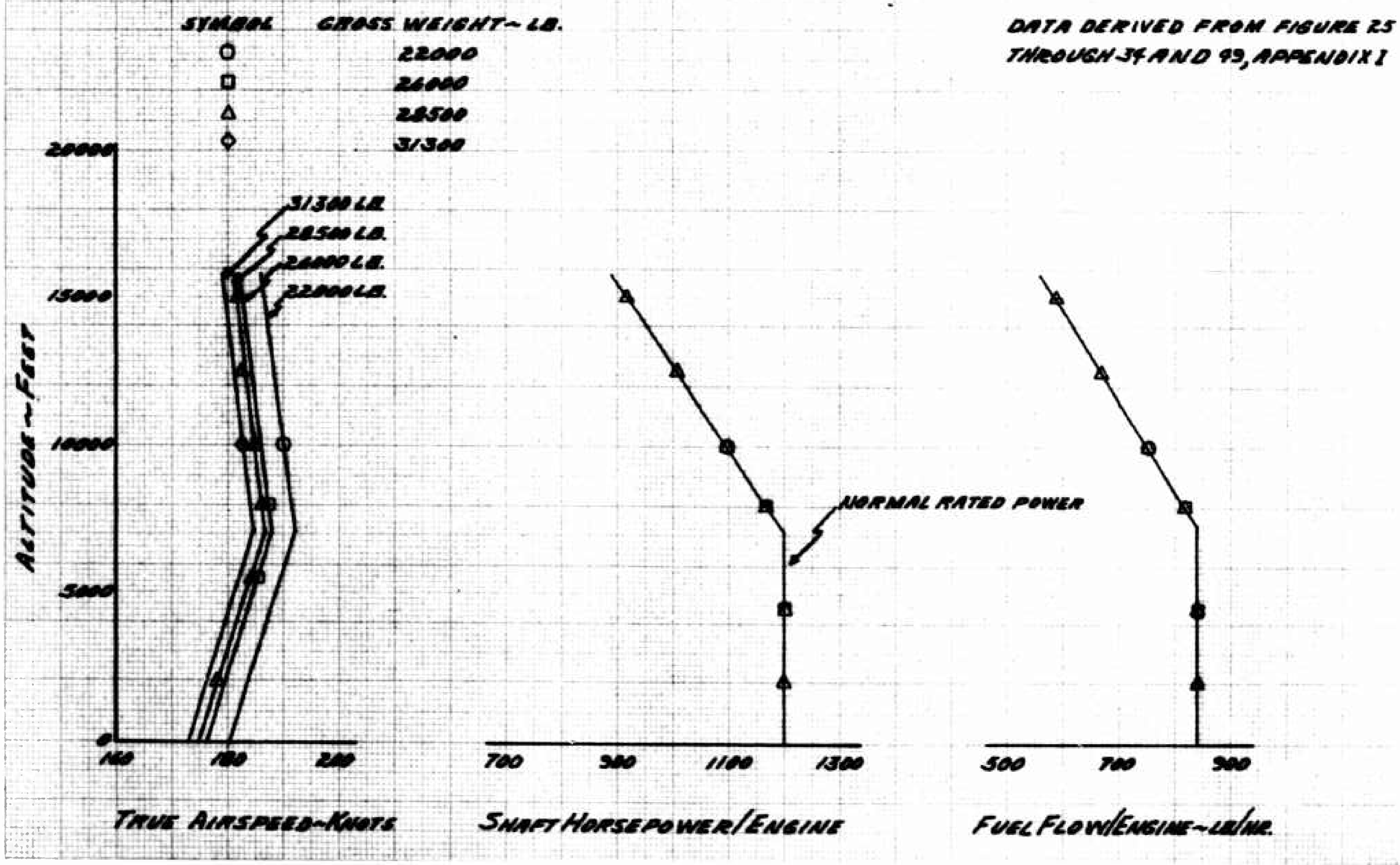
HIGH SPEED PERFORMANCE

CV-2B S/N62-4175

ENGINE MODEL R-2000-7M2

TWO ENGINE CRUISE

STANDARD DAY



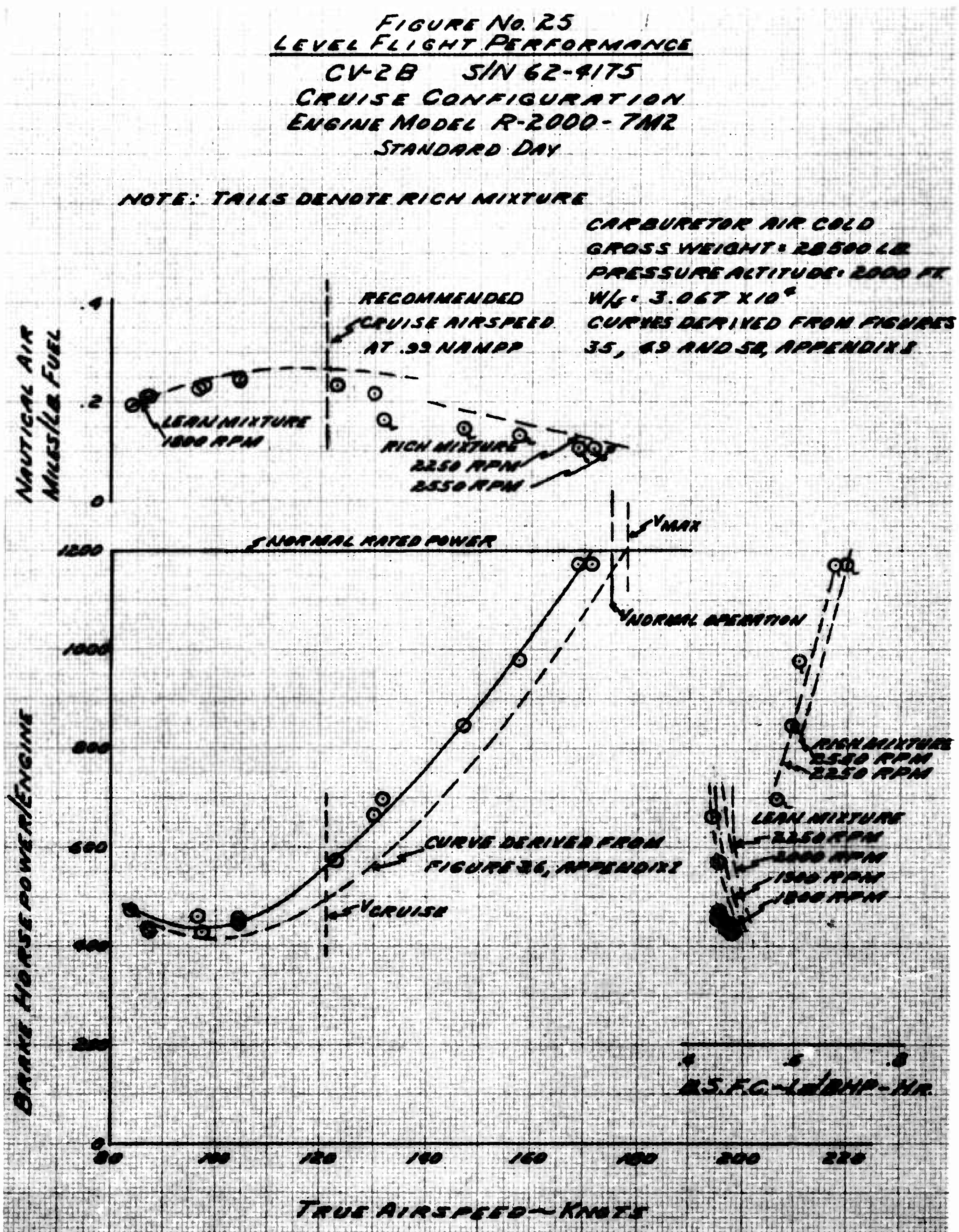


FIGURE NO. 25
LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
STANDARD DAY
NOTE: TAILS DENOTE RICH MIXTURE
CARBURETOR AIR COLD
GROSS WEIGHT = 28500 LB
PRESSURE ALTITUDE = 2000 FT
W/δ = 3.067 X 10⁴
CURVES DERIVED FROM FIGURES 35, 49 AND 58, APPENDIX I
RECOMMENDED CRUISE AIRSPEED AT .99 NAMPP
NAUTICAL AIR MILES/LB FUEL
LEAN MIXTURE 1800 RPM
RICH MIXTURE 2250 RPM 2550 RPM
NORMAL RATED POWER
VMAX
VNORMAL OPERATION
CURVE DERIVED FROM FIGURE 36, APPENDIX I
VCRUISE
RICH MIXTURE 2550 RPM 2250 RPM
LEAN MIXTURE 2250 RPM 2000 RPM 1900 RPM 1800 RPM
B.S.F.C. ~ LB/BHP-HR
BRAKE HORSEPOWER/ENGINE
TRUE AIRSPEED ~ KNOTS

FIGURE NO. 26
LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
STANDARD DAY

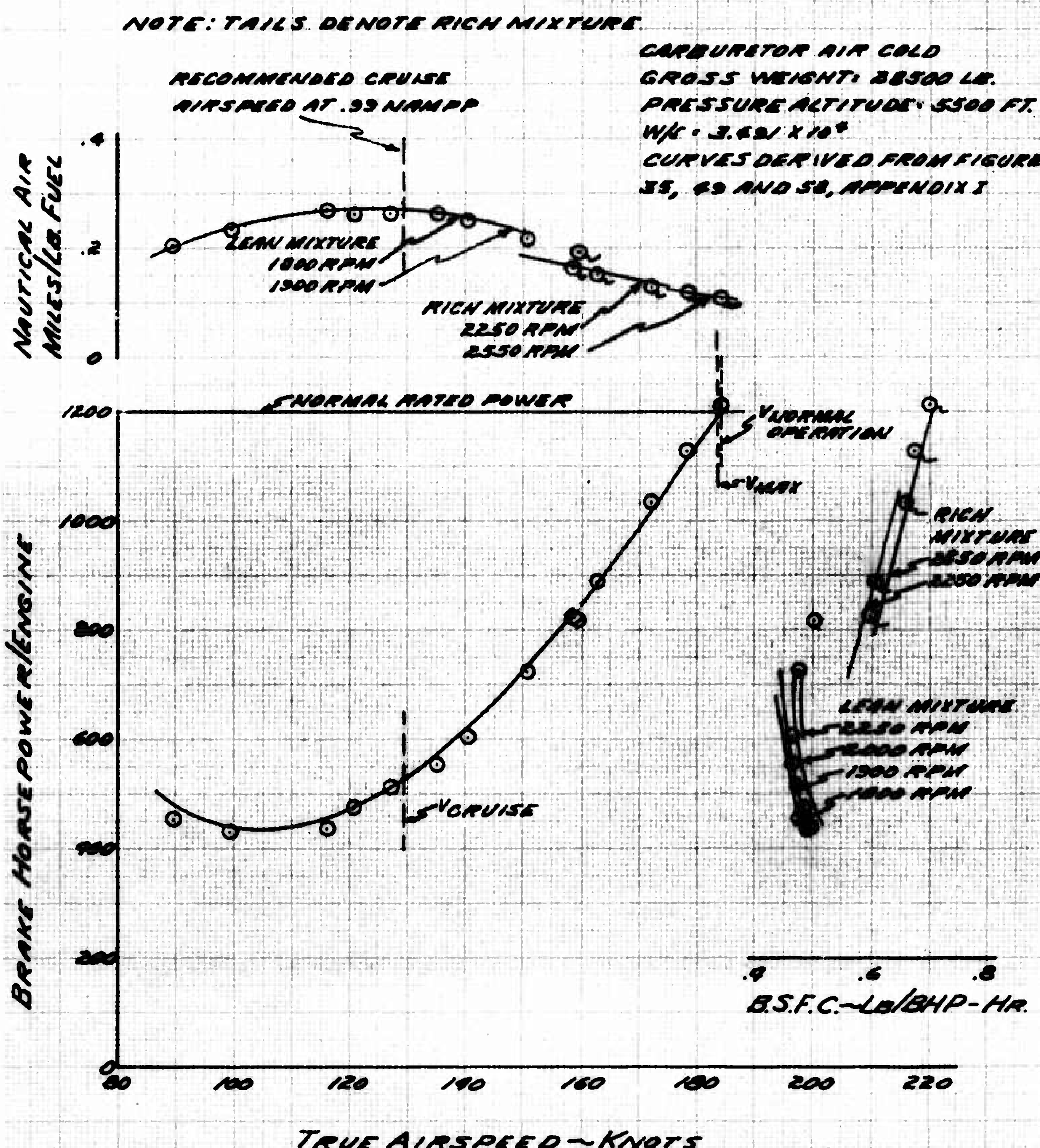


FIGURE No. 27
LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
STANDARD DAY

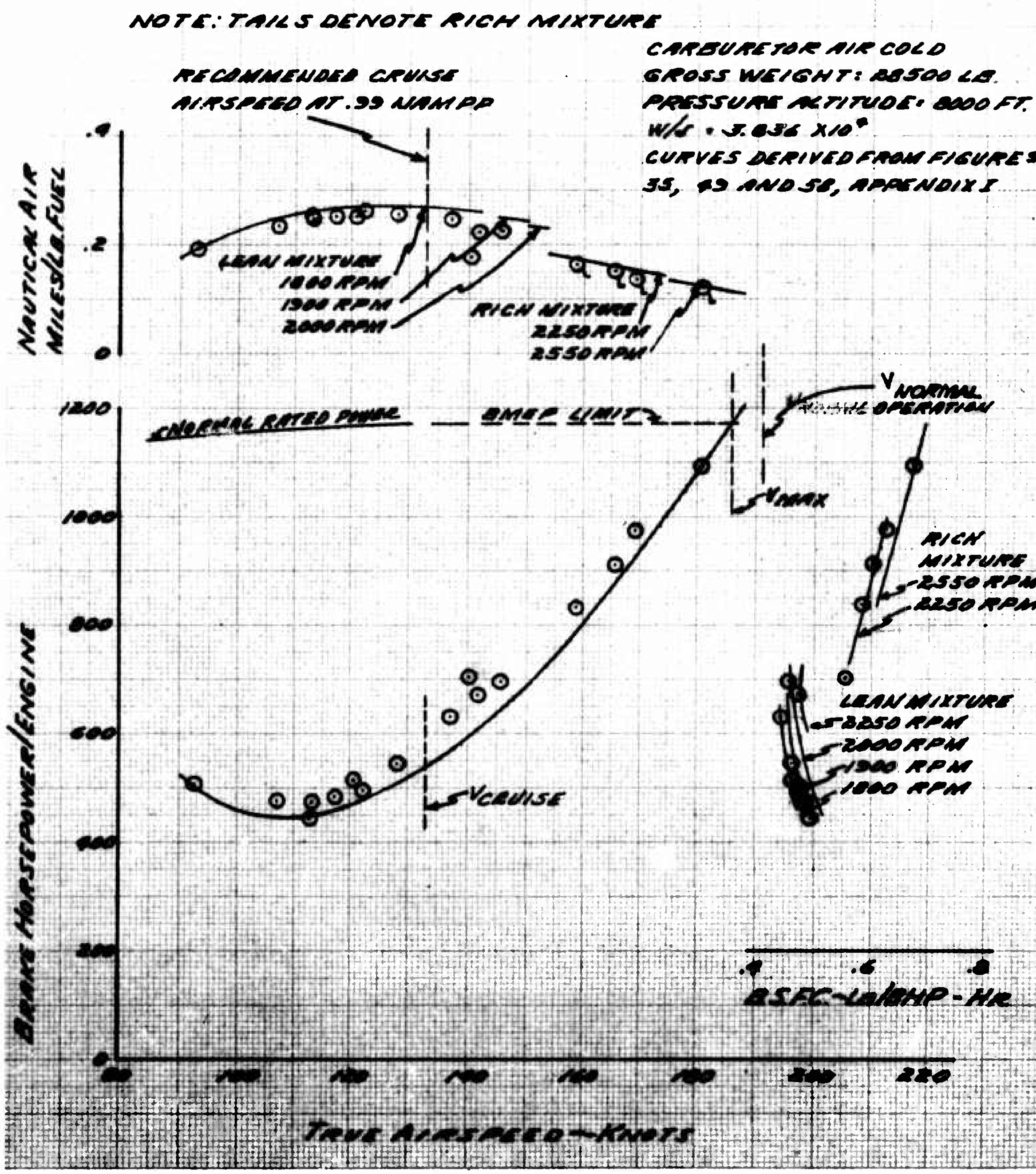
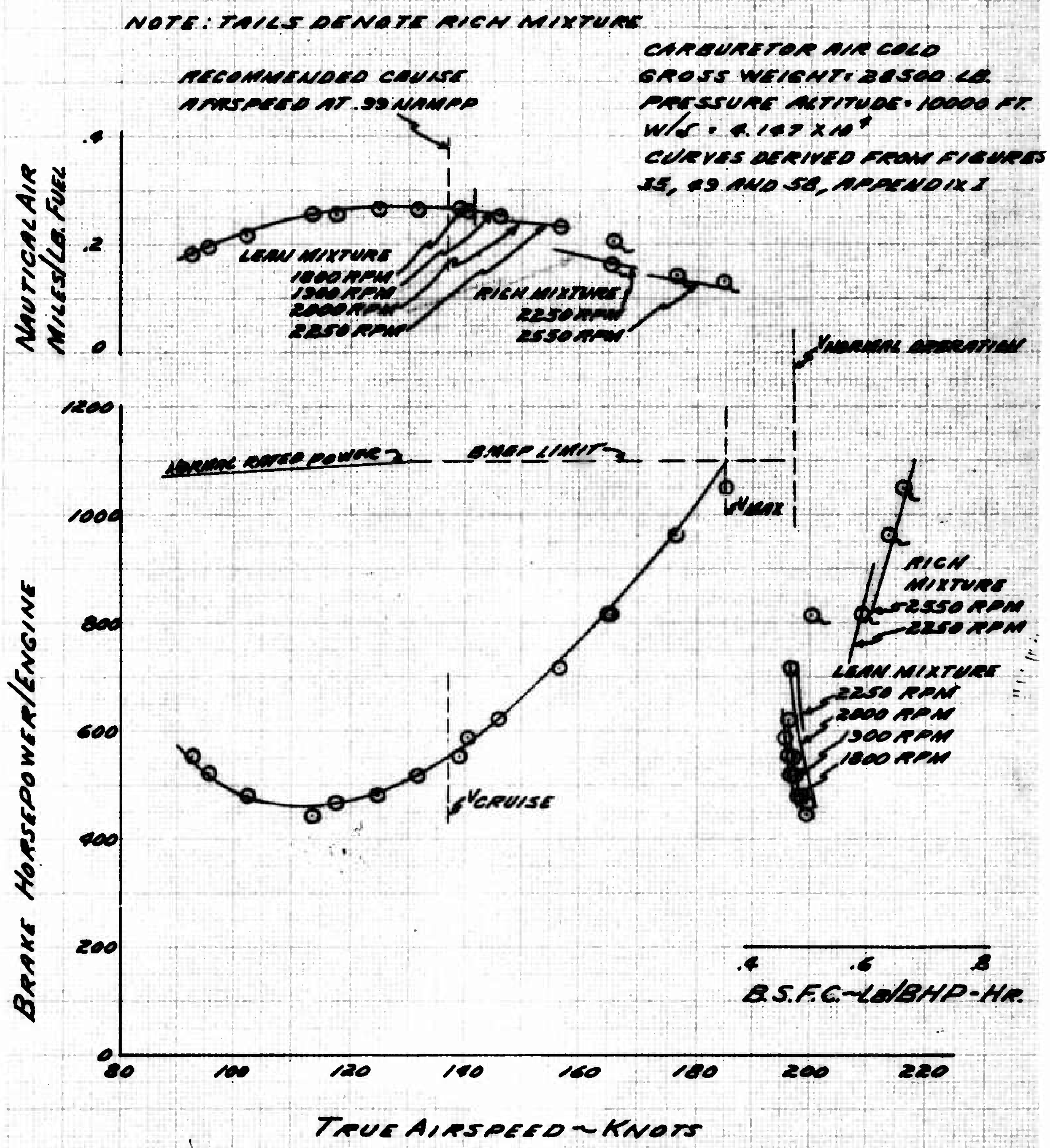


FIGURE NO. 28
LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
STANDARD DAY



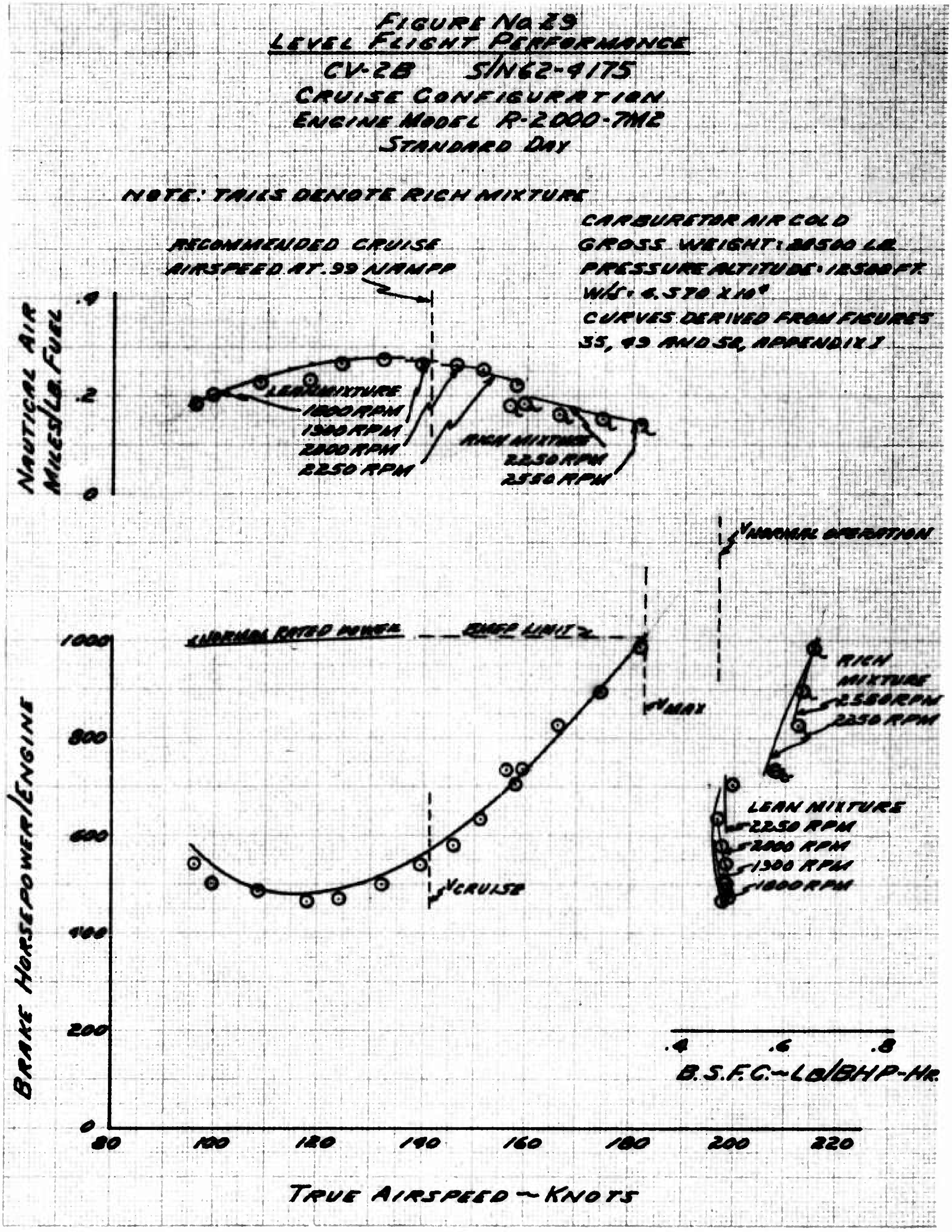


FIGURE No. 29
LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
STANDARD DAY
NOTE: TAILS DENOTE RICH MIXTURE
CARBURETOR AIR COLD
GROSS WEIGHT: 28500 LB.
PRESSURE ALTITUDE: 12500 FT.
CURVES DERIVED FROM FIGURES 35, 49 AND 58, APPENDIX I
RECOMMENDED CRUISE AIRSPEED AT .99 NAMPP
NAUTICAL AIR MILES/LB. FUEL
LEAN MIXTURE
1800 RPM
1900 RPM
2200 RPM
2250 RPM
RICH MIXTURE
2250 RPM
2550 RPM
NORMAL RATED POWER
VNORMAL OPERATION
VMAX
VCRUISE
BRAKE HORSEPOWER/ENGINE
B.S.F.C.~LB/BHP-HR.
TRUE AIRSPEED ~ KNOTS

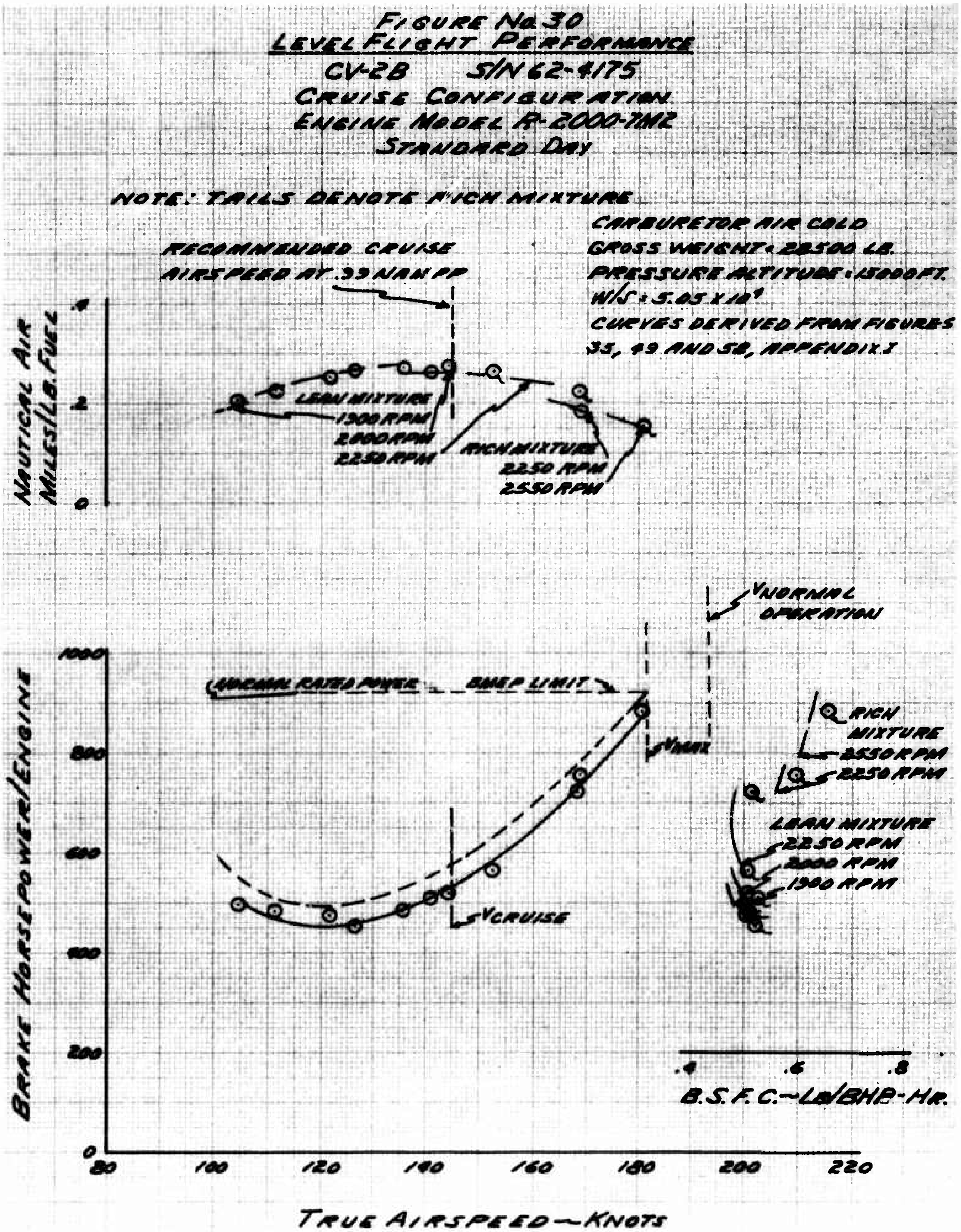


FIGURE No. 30
LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
STANDARD DAY
NOTE: TAILS DENOTE RICH MIXTURE
CARBURETOR AIR COLD
GROSS WEIGHT = 28500 LB.
PRESSURE ALTITUDE = 15000 FT.
CURVES DERIVED FROM FIGURES 35, 49 AND 58, APPENDIX I
RECOMMENDED CRUISE AIRSPEED AT .99 MAX PP
NAUTICAL AIR MILES/LB. FUEL
LEAN MIXTURE
1900 RPM
2000 RPM
2250 RPM
RICH MIXTURE
2250 RPM
2550 RPM
VNORMAL OPERATION
NORMAL RATED POWER — BMEP LIMIT
VMAX
VCRUISE
BRAKE HORSEPOWER/ENGINE
B.S.F.C.~LB/BHP-HR.
TRUE AIRSPEED~KNOTS

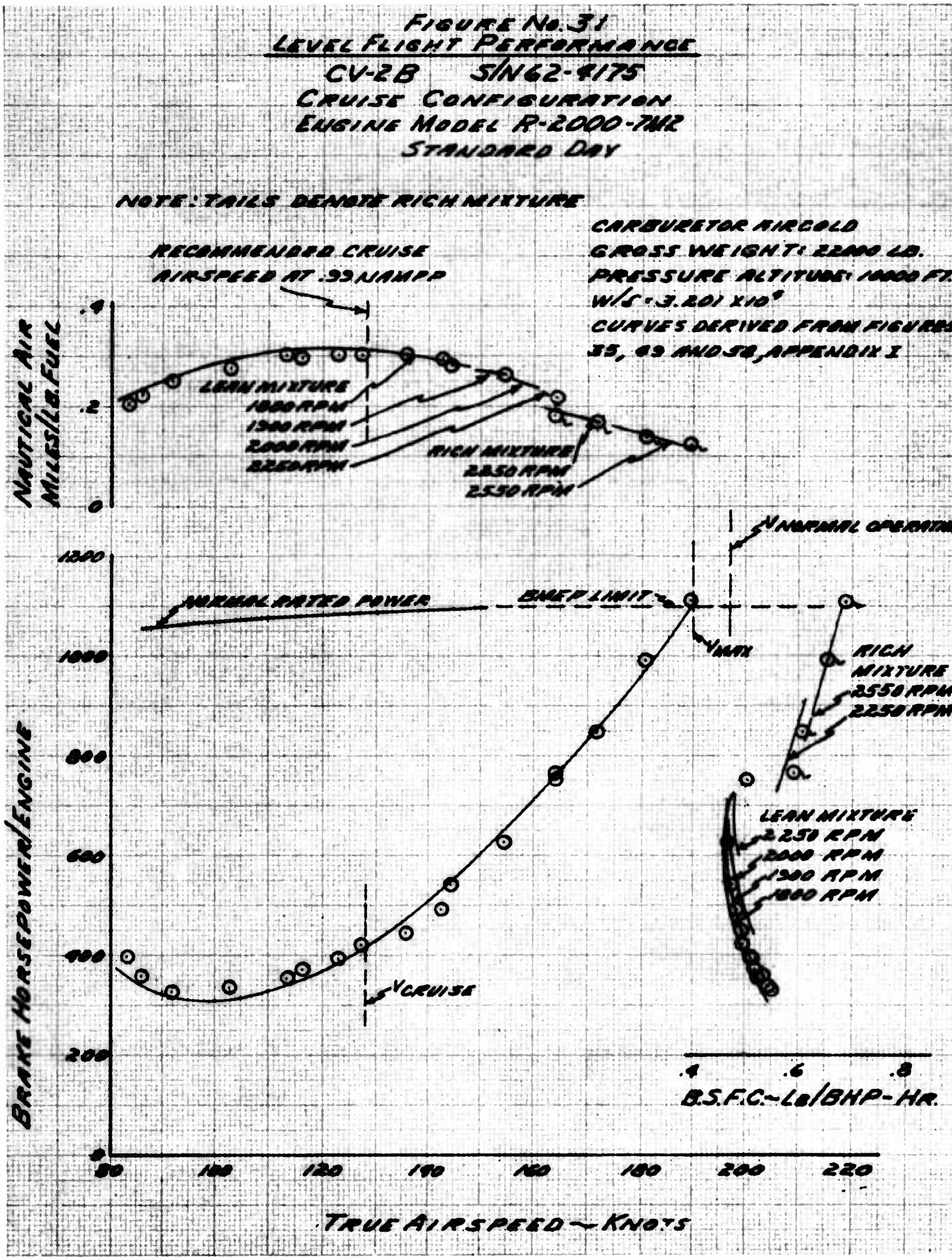


FIGURE No. 31
LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
STANDARD DAY
NOTE: TAILS DENOTE RICH MIXTURE
RECOMMENDED CRUISE AIRSPEED AT .99 NAMPP
CARBURETOR AIR COLD
GROSS WEIGHT: 22000 LB.
PRESSURE ALTITUDE: 10000 FT.
W/S = 3.201 X10⁹
CURVES DERIVED FROM FIGURES 35, 49 AND 58, APPENDIX I
NAUTICAL AIR MILES/LB. FUEL
LEAN MIXTURE
1800 RPM
1900 RPM
2000 RPM
2250 RPM
RICH MIXTURE
2250 RPM
2550 RPM
NORMAL RATED POWER
BMEP LIMIT
V MAX
V NORMAL OPERATING
RICH MIXTURE
2550 RPM
2250 RPM
LEAN MIXTURE
2250 RPM
2000 RPM
1900 RPM
1800 RPM
V CRUISE
BRAKE HORSEPOWER/ENGINE
B.S.F.C.~LB/BHP-HR.
TRUE AIRSPEED ~ KNOTS

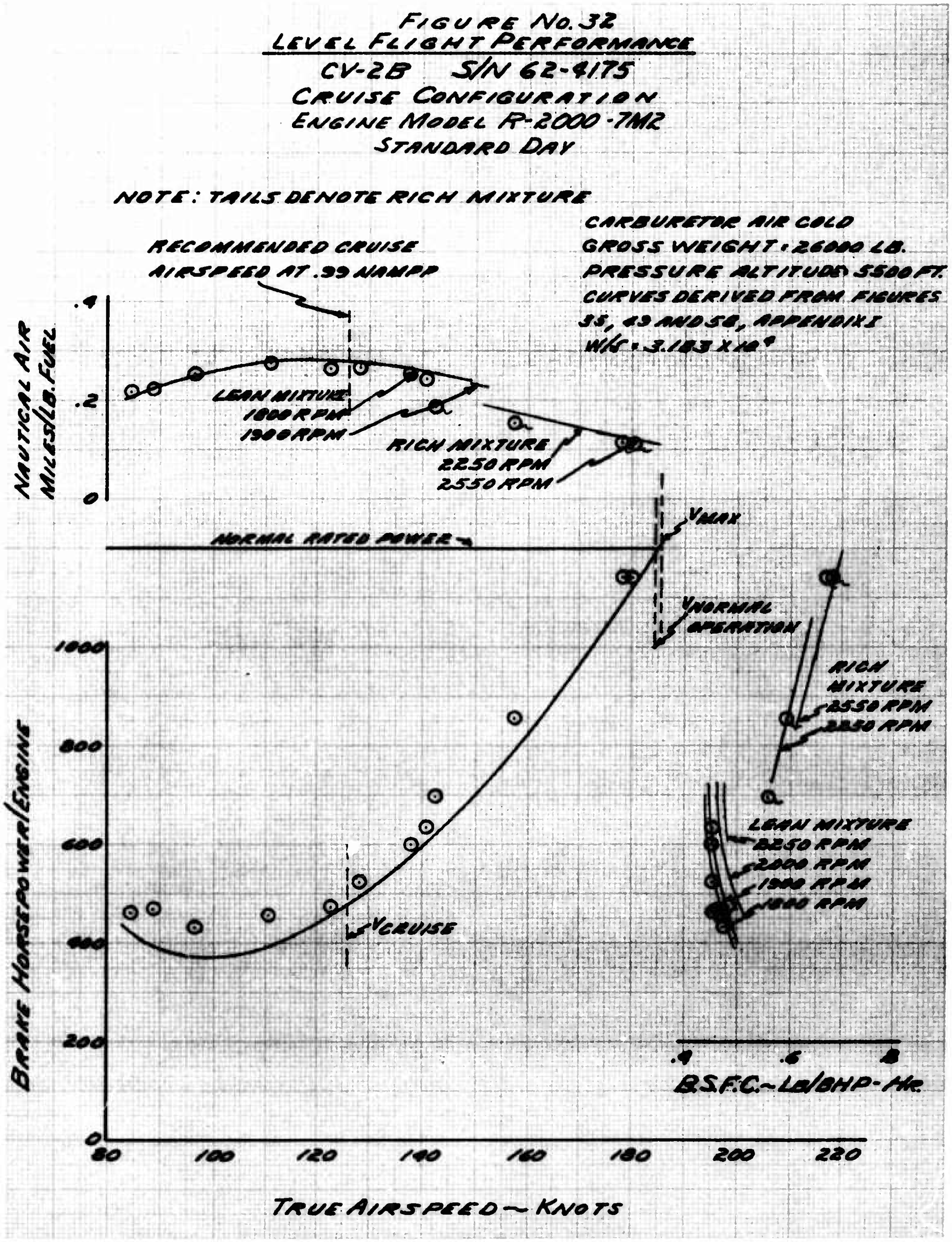
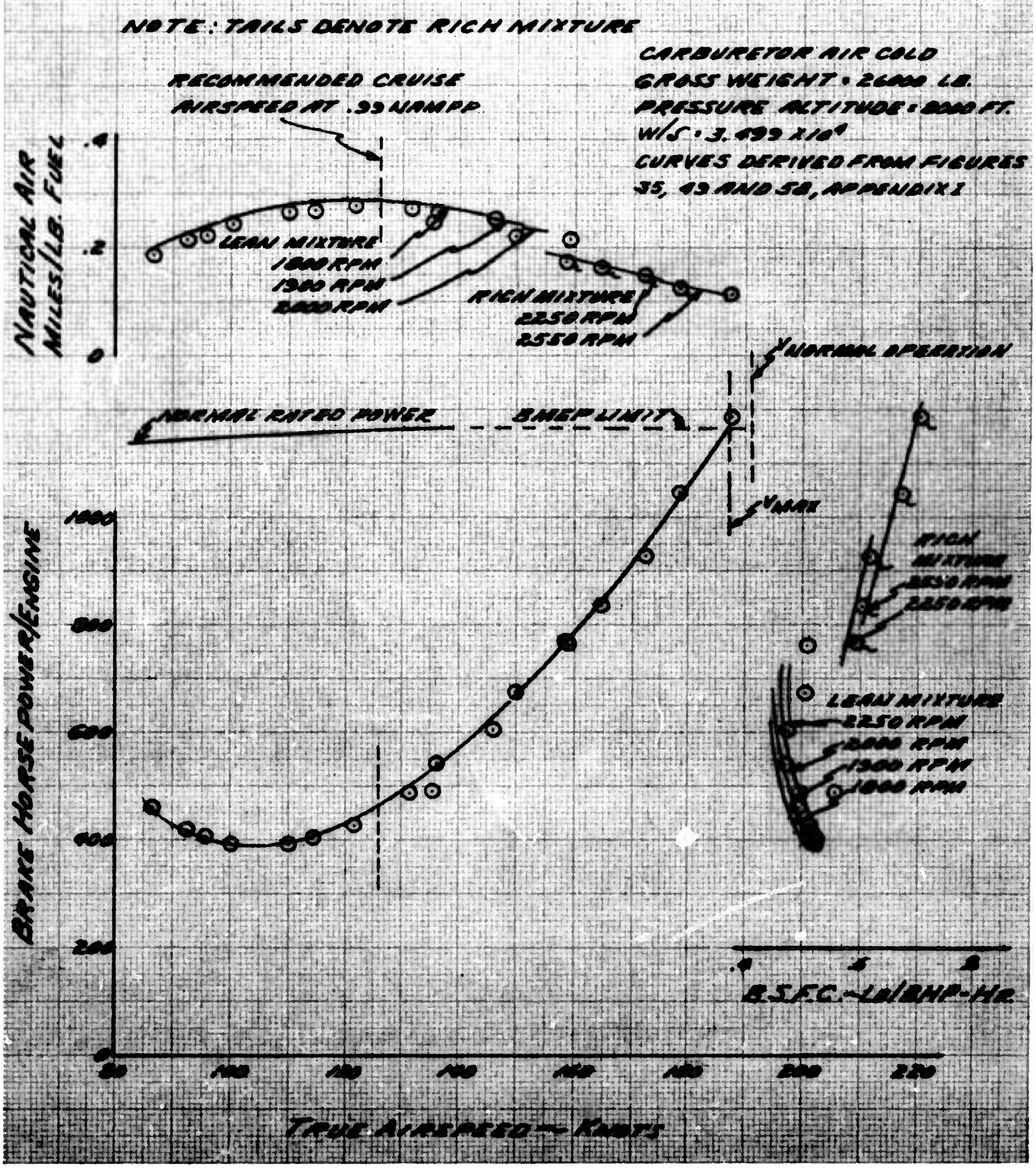
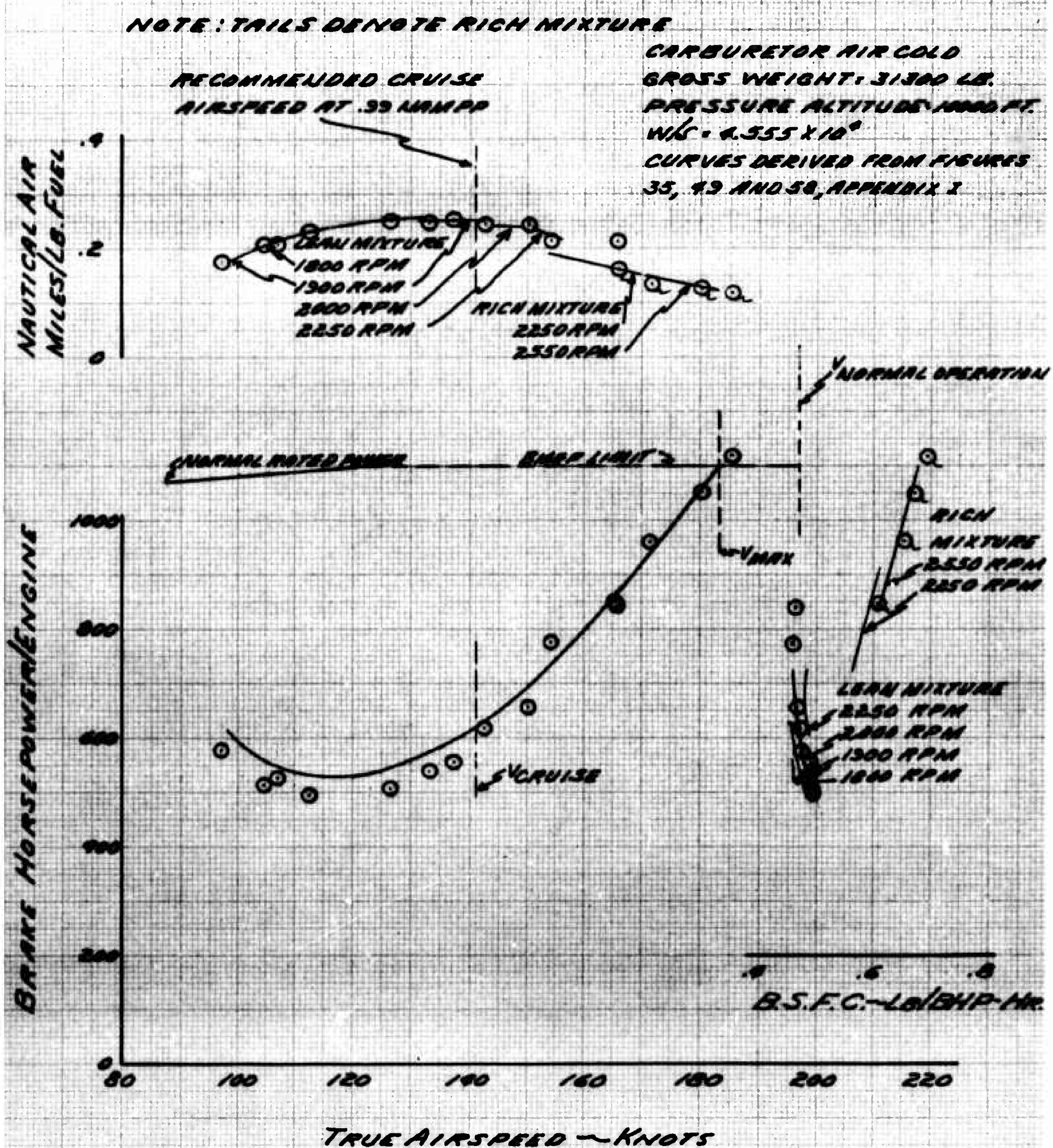


FIGURE NO. 32
LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
STANDARD DAY
NOTE: TAILS DENOTE RICH MIXTURE
CARBURETOR AIR COLD
GROSS WEIGHT = 26000 LB.
PRESSURE ALTITUDE 5500 FT.
CURVES DERIVED FROM FIGURES
35, 43 AND 58, APPENDIX I
RECOMMENDED CRUISE
AIRSPEED AT .99 NAMPP
NAUTICAL AIR
MILES/LB. FUEL
LEAN MIXTURE
1800 RPM
1900 RPM
RICH MIXTURE
2250 RPM
2550 RPM
NORMAL RATED POWER
VMAX
VNORMAL
OPERATION
VCRUISE
BRAKE HORSEPOWER/ENGINE
B.S.F.C.~LB/BHP-HR.
2000 RPM
TRUE AIRSPEED ~ KNOTS

FIGURE NO. 33
LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
STANDARD DAY



## FIGURE NO. 34
## LEVEL FLIGHT PERFORMANCE
### CV-2B S/N 62-4175
### CRUISE CONFIGURATION
### ENGINE MODEL R-2000-7M2
### STANDARD DAY



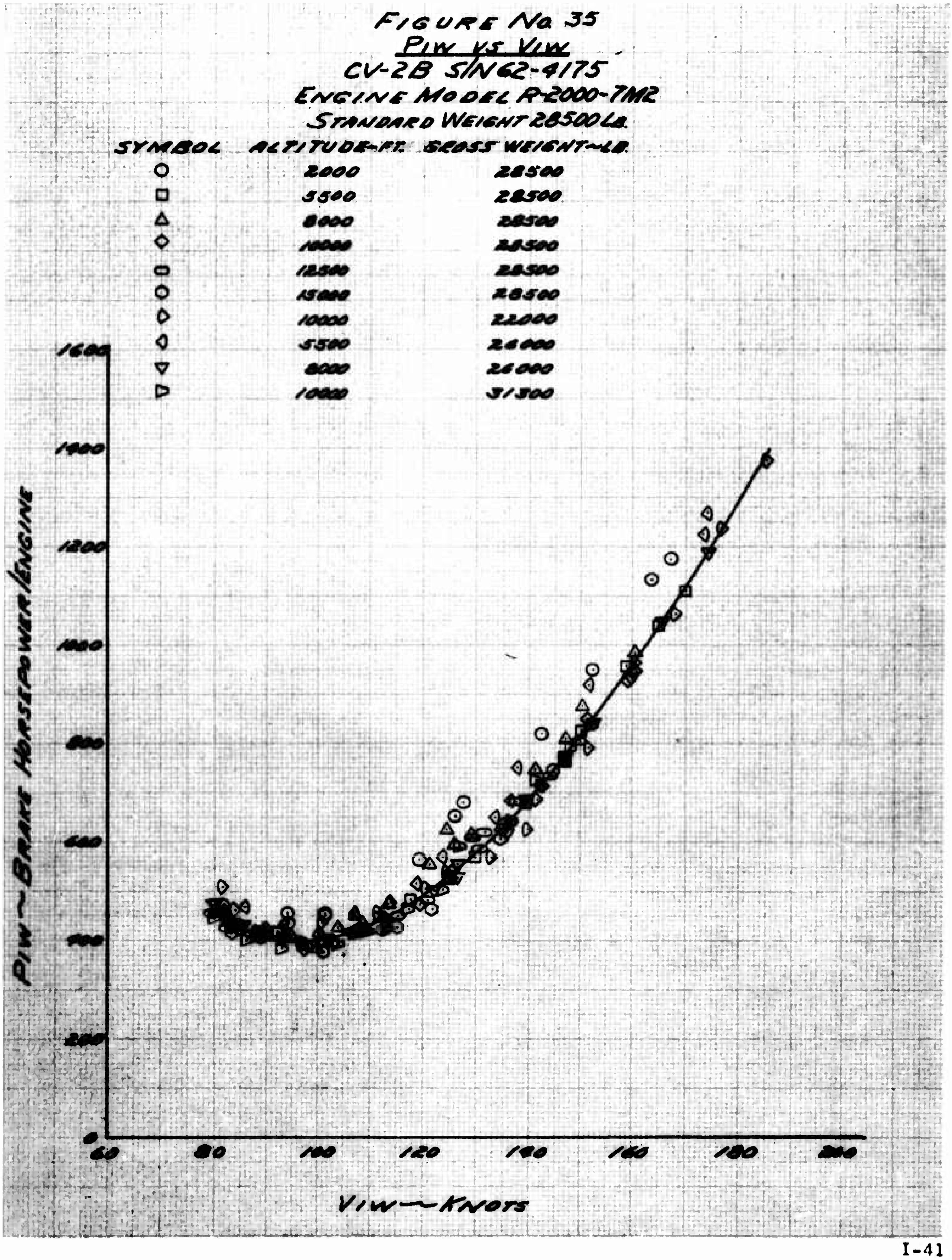
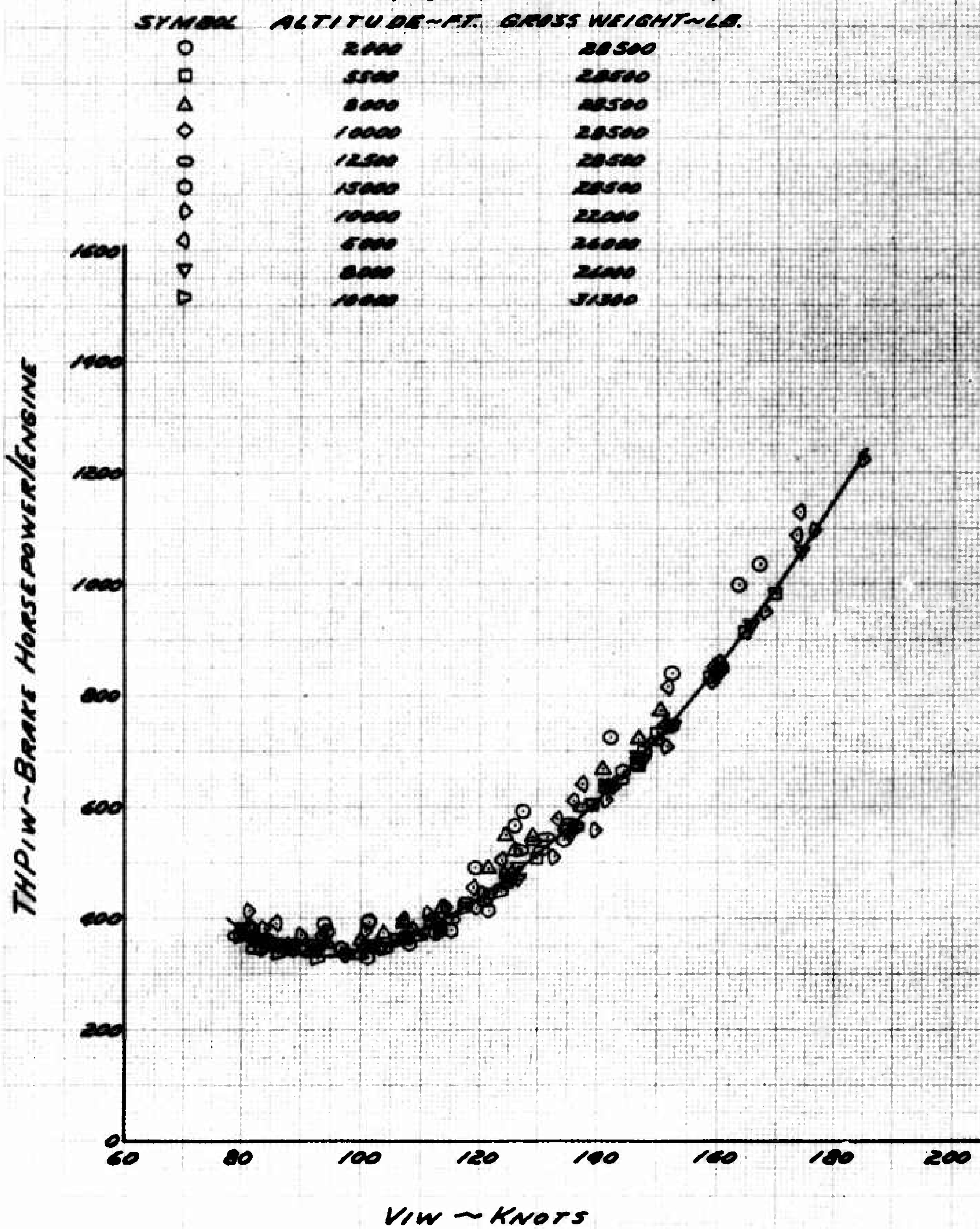


FIGURE No. 35
PIW VS VIW
CV-2B S/N 62-4175
ENGINE MODEL R-2000-7M2
STANDARD WEIGHT 28500 LB.
SYMBOL ALTITUDE-FT. GROSS WEIGHT~LB.
2000 28500
5500 28500
8000 28500
10000 28500
12500 28500
15000 28500
10000 22000
5500 24000
8000 26000
10000 31300
PIW ~ BRAKE HORSEPOWER/ENGINE
VIW ~ KNOTS

FIGURE No. 36
THPIW VS VIW
CV-2B S/N62-4175
ENGINE MODEL R-2000-7M2
STANDARD WEIGHT 28500 LB.



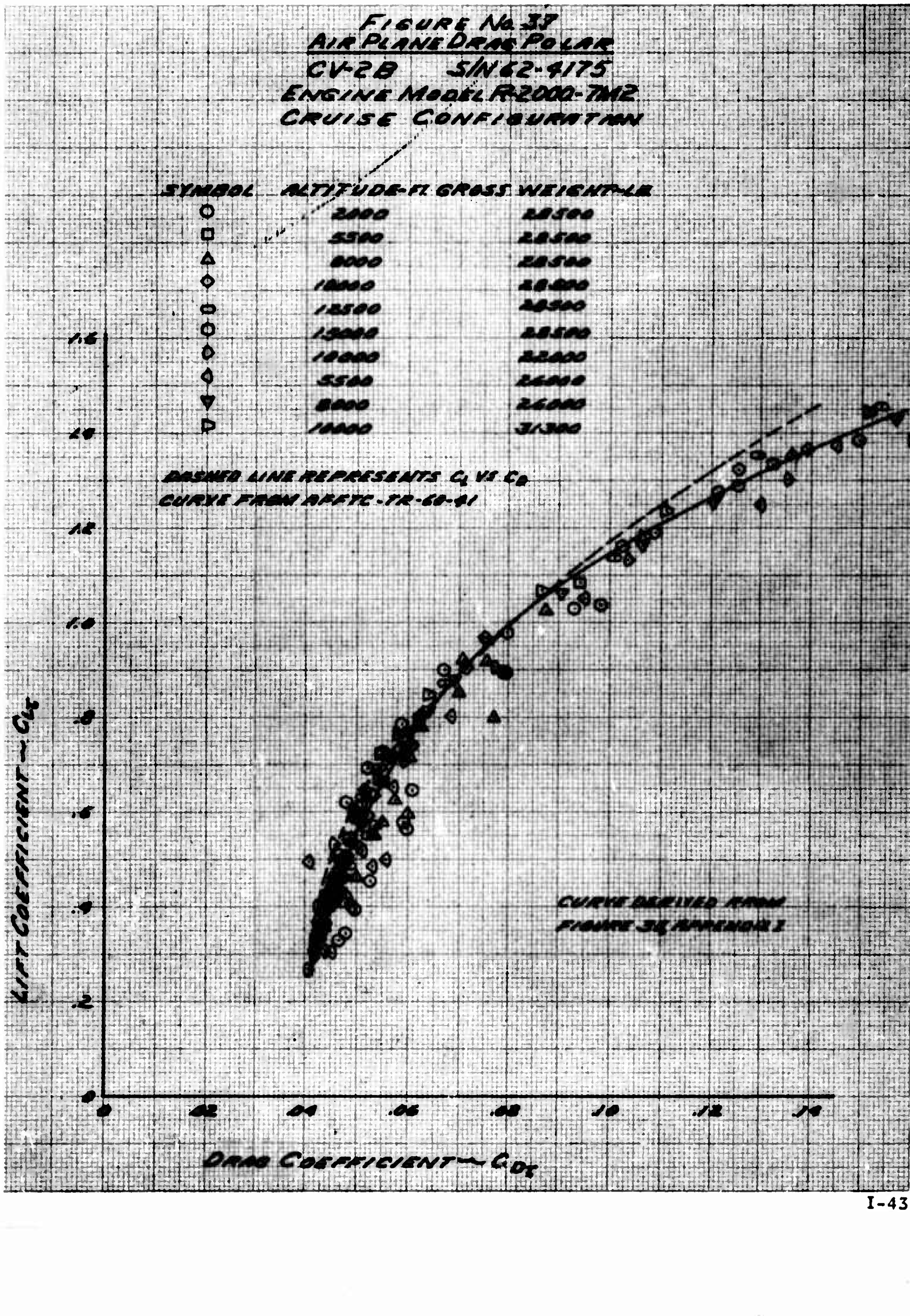
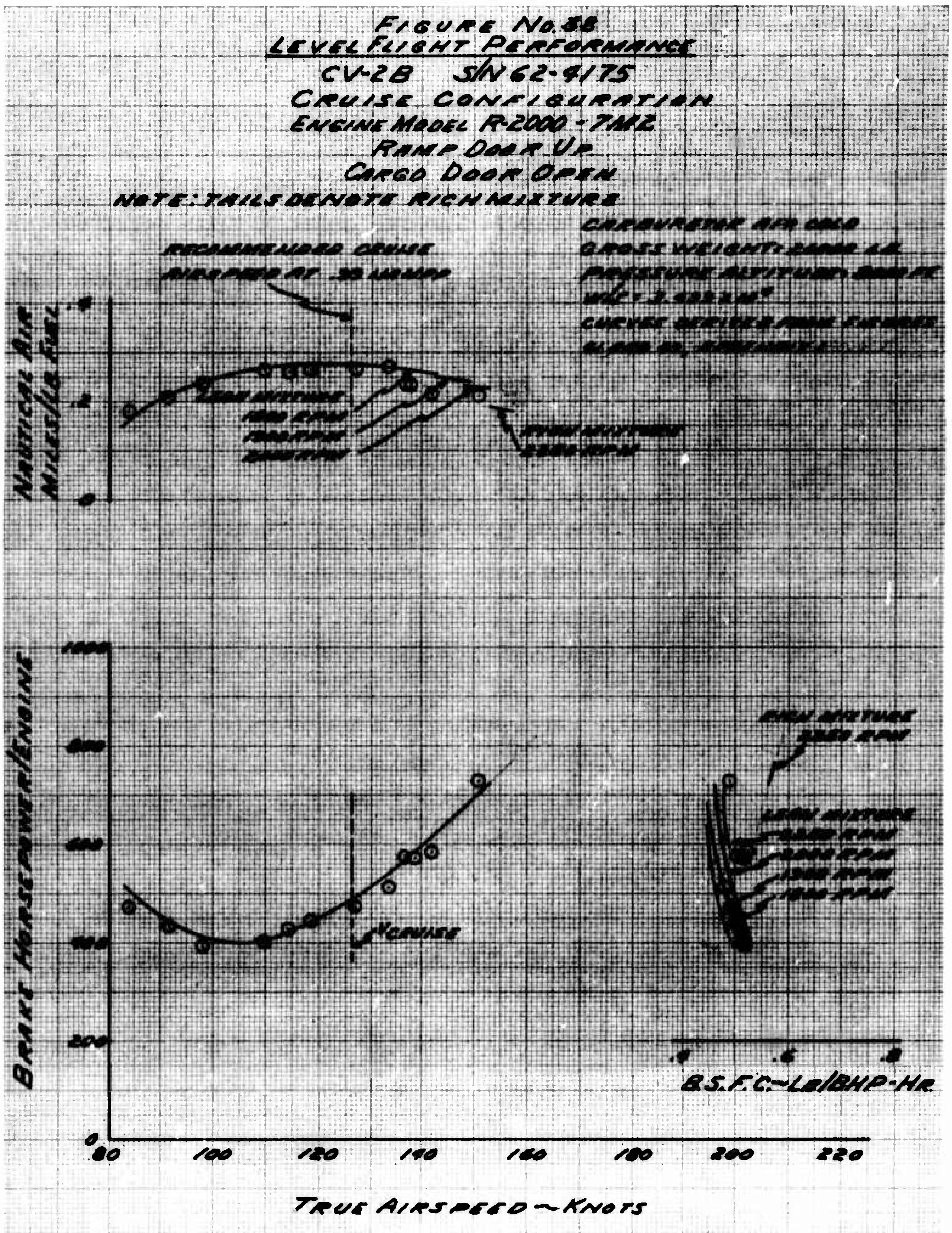


FIGURE No. 37
AIR PLANE DRAG POLAR
CV-2B S/N 62-4175
ENGINE MODEL R-2000-7M2
CRUISE CONFIGURATION
SYMBOL ALTITUDE-FT. GROSS WEIGHT-LB
2000 28500
5500 28500
8000 28500
10000
12500
15000 28500
10000
5500
8000 26000
10000 31300
DASHED LINE REPRESENTS CL VS CD
CURVE FROM AFFTC-TR-60-41
CURVE DERIVED FROM FIGURE 38, APPENDIX I
LIFT COEFFICIENT ~ CLT
DRAG COEFFICIENT ~ CDT
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
.02
.04
.06
.08
.10
.12
.14



LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
RAMP DOOR UP
CARGO DOOR OPEN
NOTE: TAILS DENOTE RICH MIXTURE
NAUTICAL AIR MILES/LB FUEL
BRAKE HORSEPOWER/ENGINE
VCRUISE
B.S.F.C.~LB/BHP-HR
TRUE AIRSPEED~KNOTS

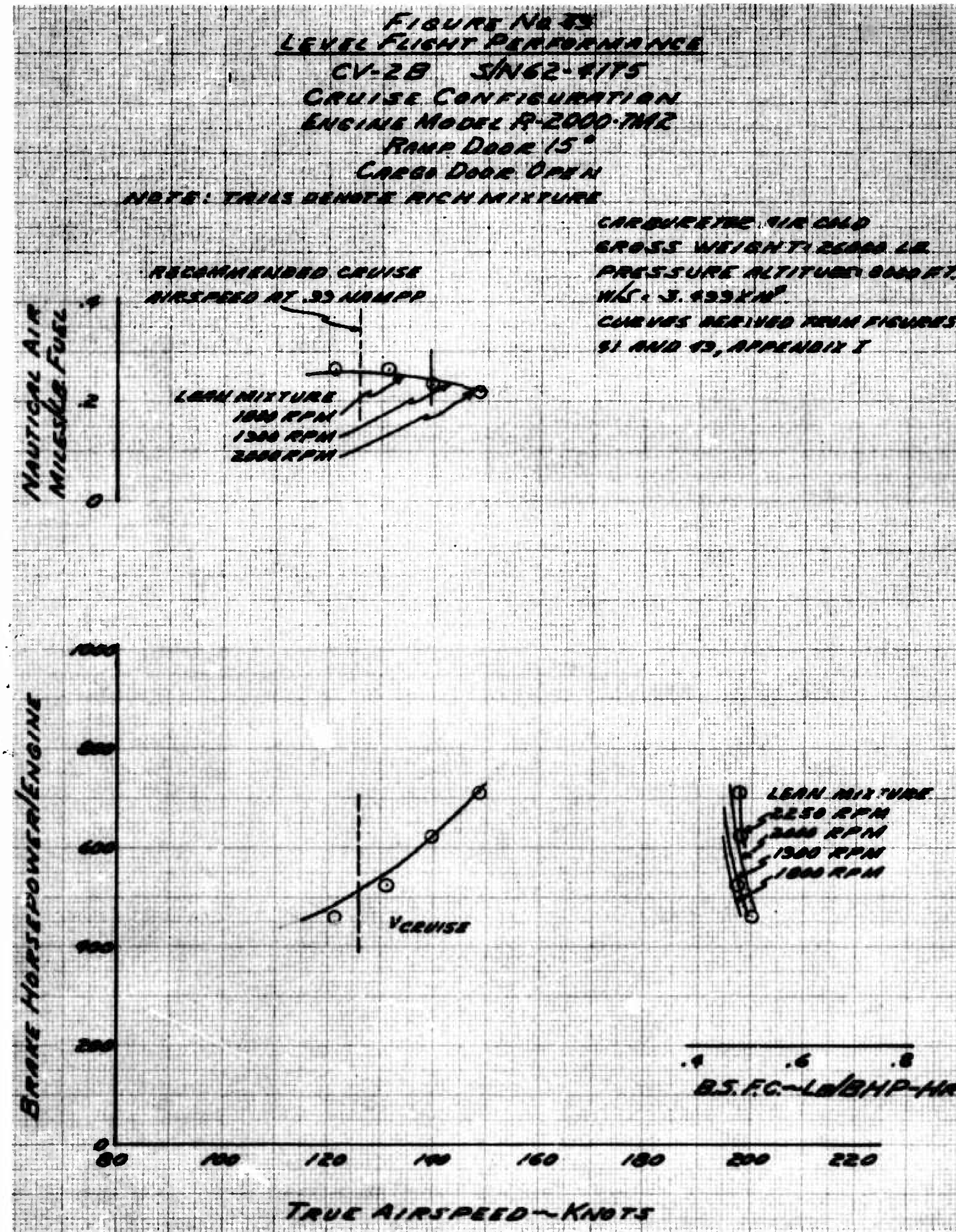

LEVEL FLIGHT PERFORMANCE
CV-2B S/N62-4175
CRUISE CONFIGURATION
ENGINE MODEL R-2000-7M2
RAMP DOOR 15°
CARGO DOOR OPEN
NOTE: TAILS DENOTE RICH MIXTURE
CARBURETOR AIR COLD
PRESSURE ALTITUDE
CURVES DERIVED FROM FIGURES
91 AND 93, APPENDIX I
RECOMMENDED CRUISE
AIRSPEED AT .99 NAMPP
NAUTICAL AIR MILES/LB FUEL
LEAN MIXTURE
1800 RPM
1900 RPM
2000 RPM
BRAKE HORSEPOWER/ENGINE
LEAN MIXTURE
2250 RPM
2000 RPM
1900 RPM
1800 RPM
VCRUISE
B.S.F.C.~LB/BHP-HR
TRUE AIRSPEED~KNOTS

FIGURE NO. 40

LEVEL FLIGHT PERFORMANCE

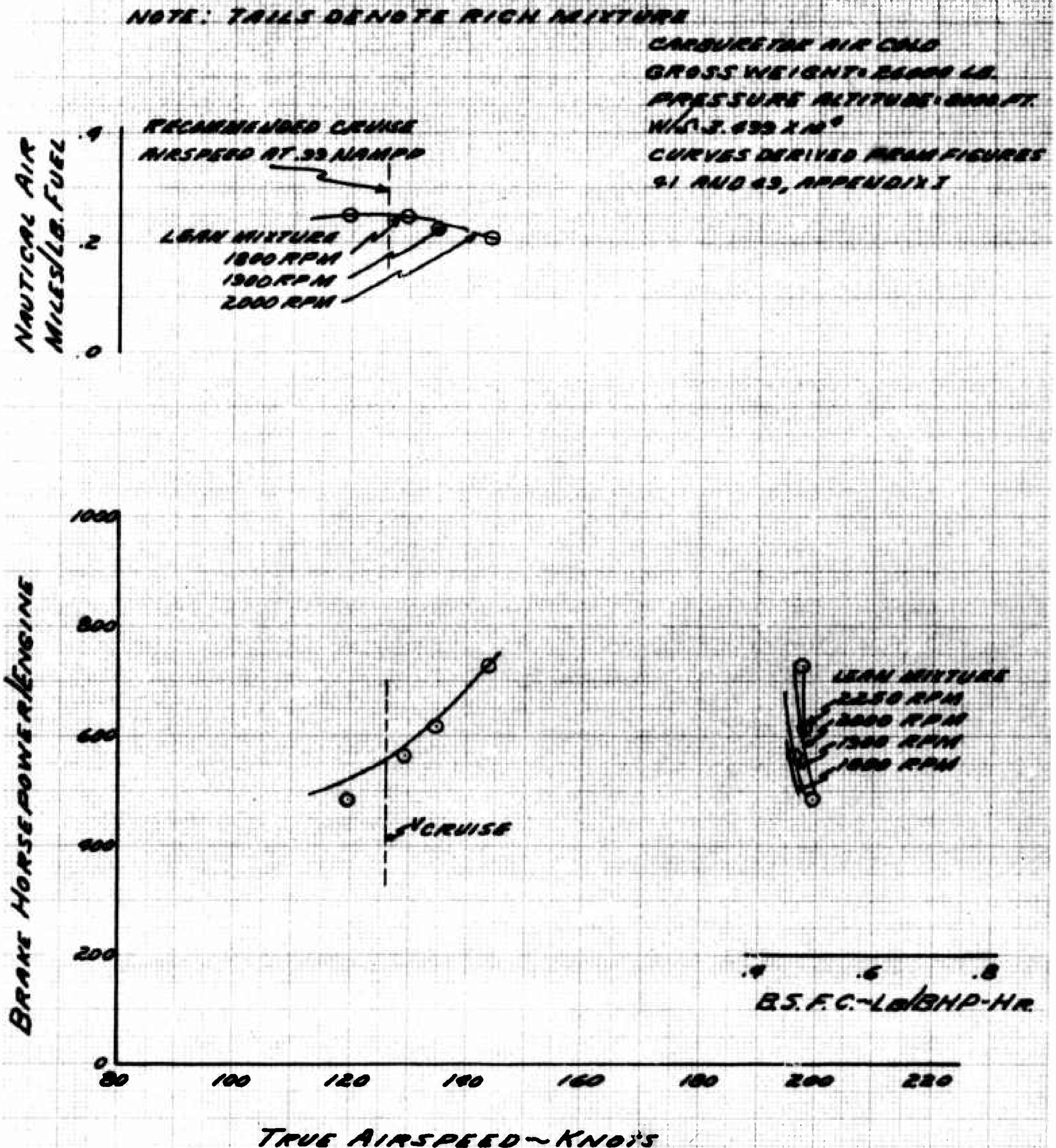
CV-2B S/N 62-4175

CRUISE CONFIGURATION

ENGINE MODEL R-2000-7M2

RAMP DOOR 30°

CARGO DOOR OPEN



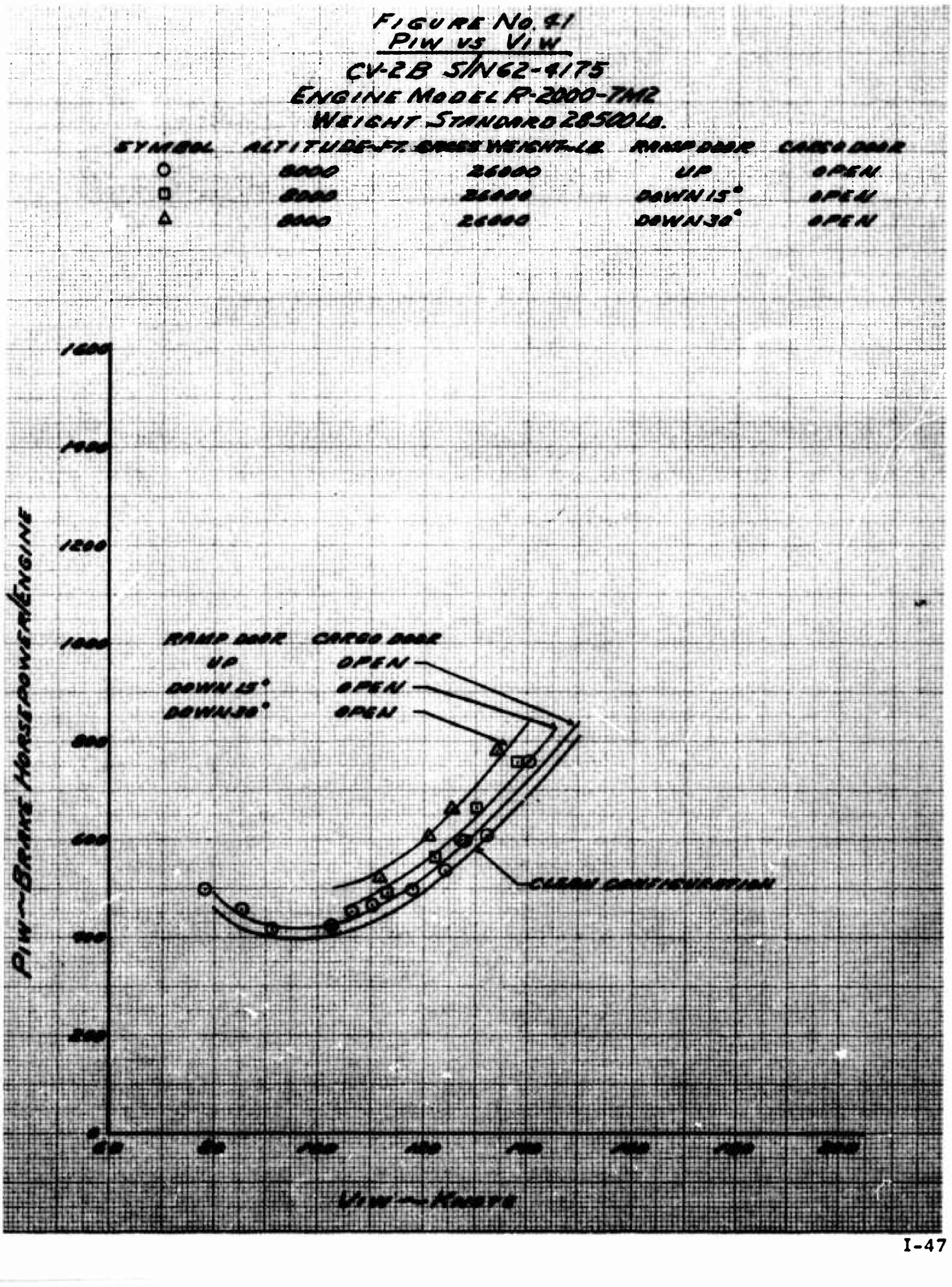


FIGURE NO. 41
PIW VS VIW
CV-2B S/N62-4175
ENGINE MODEL R-2000-7M2
WEIGHT STANDARD 28500 LB.
SYMBOL
ALTITUDE-FT.
GROSS WEIGHT-LB.
RAMP DOOR
CARGO DOOR
8000
26000
UP
OPEN
DOWN 15°
DOWN 30°
RAMP DOOR
CARGO DOOR
UP
OPEN
DOWN 15°
OPEN
DOWN 30°
OPEN
CLEAN CONFIGURATION
PIW ~ BRAKE HORSEPOWER/ENGINE
1600
1200
1000
0
VIW ~ KNOTS

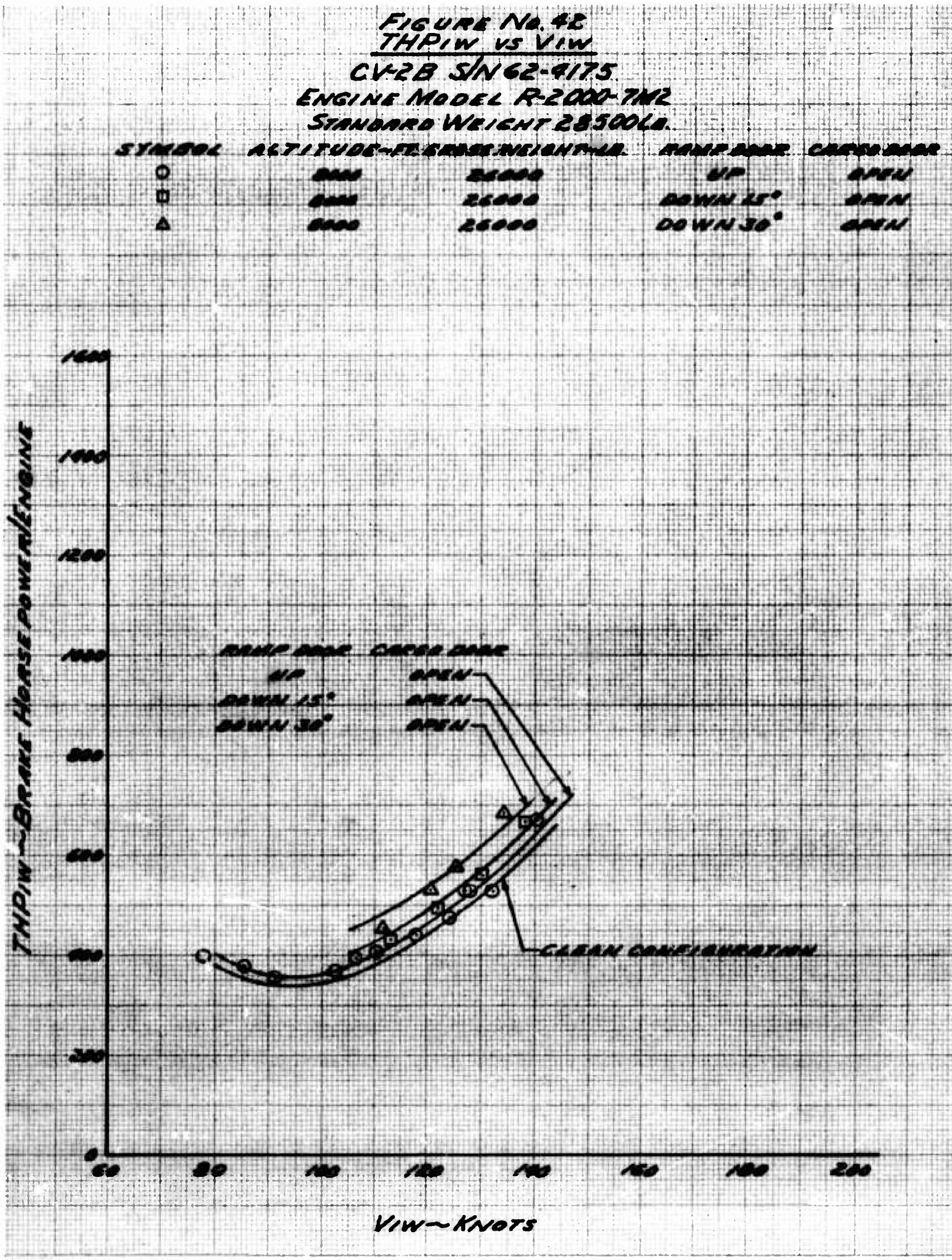


FIGURE No. 42
THPIW vs VIW
CV-2B S/N 62-4175
ENGINE MODEL R-2000-7M2
STANDARD WEIGHT 28500LB.
SYMBOL ALTITUDE~FT. GROSS WEIGHT~LB. RAMP DOOR CARGO DOOR
8000 26000 UP OPEN
8000 26000 DOWN 15° OPEN
8000 26000 DOWN 30° OPEN
RAMP DOOR CARGO DOOR
UP OPEN
DOWN 15° OPEN
DOWN 30° OPEN
CLEAN CONFIGURATION
THPIW~BRAKE HORSEPOWER/ENGINE
VIW~KNOTS

FIGURE NO. 43
AIR PLANE DRAG POLAR
CV-2B S/N 62-4175
ENGINE MODEL R-2000-7M2
CRUISE CONFIGURATION
STANDARD WEIGHT 28500 LB.

| SYMBOL | ALTITUDE-FT. | GROSS WEIGHT~LB. | RAMP DOOR | CARGO DOOR |
|---|---|---|---|---|
| ○ | 8000 | 26000 | UP | OPEN |
| □ | 8000 | 26000 | DOWN 15° | OPEN |
| △ | 8000 | 26000 | DOWN 30° | OPEN |

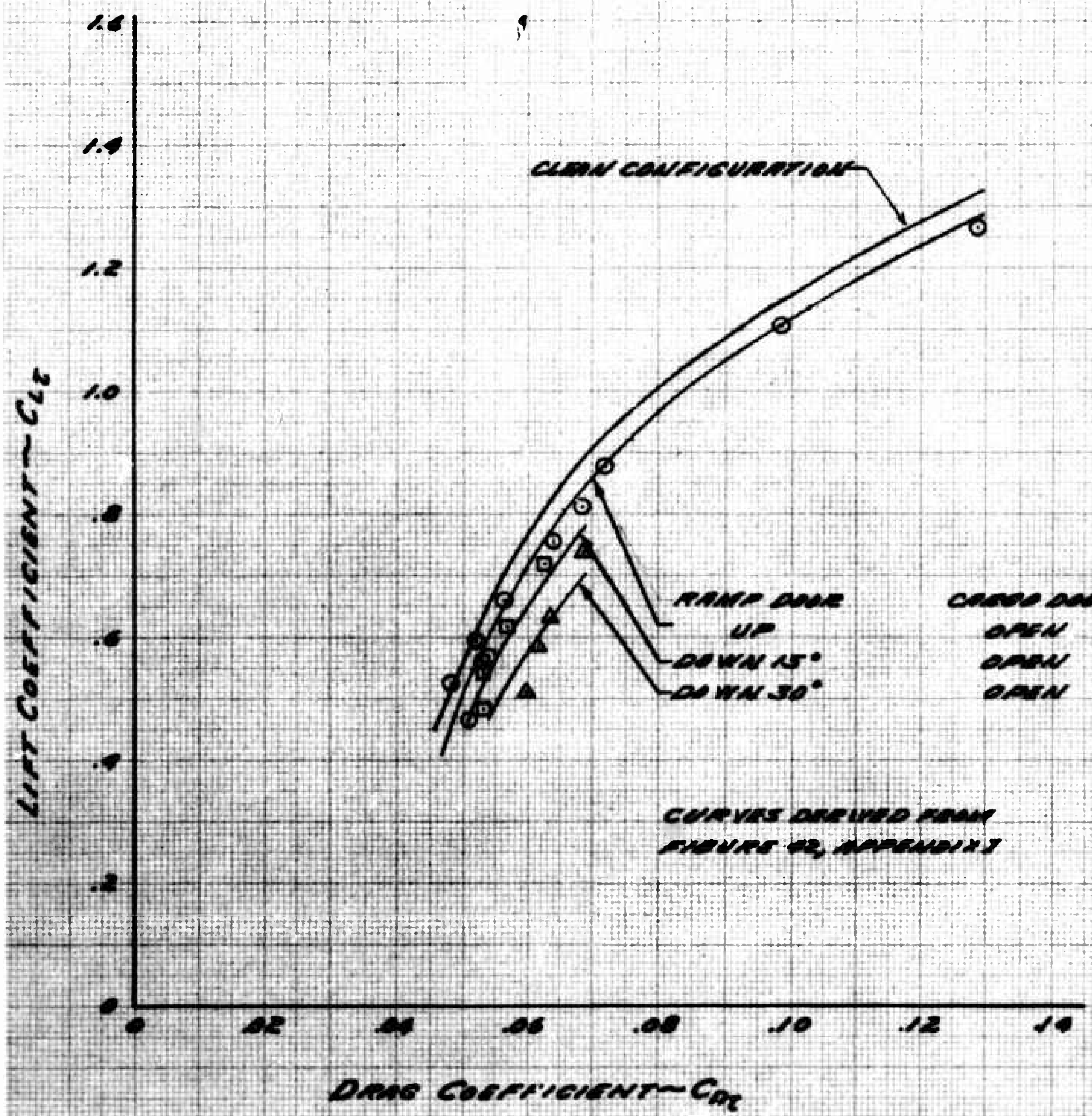
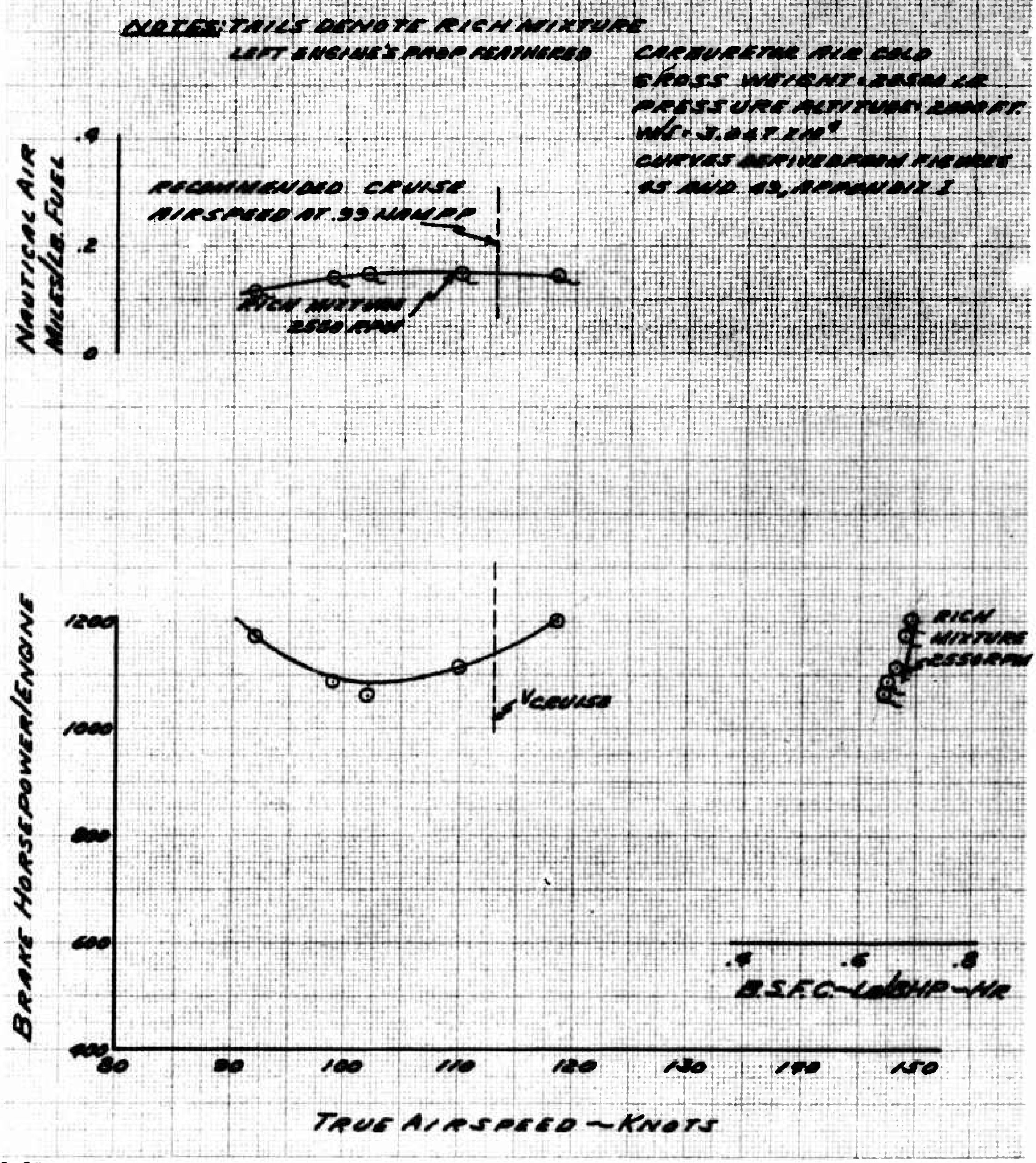


FIGURE No. 44
LEVEL FLIGHT PERFORMANCE
CV-2B S/N 62-4175
CRUISE CONFIGURATION
SINGLE ENGINE
ENGINE MODEL R-2000-7M2



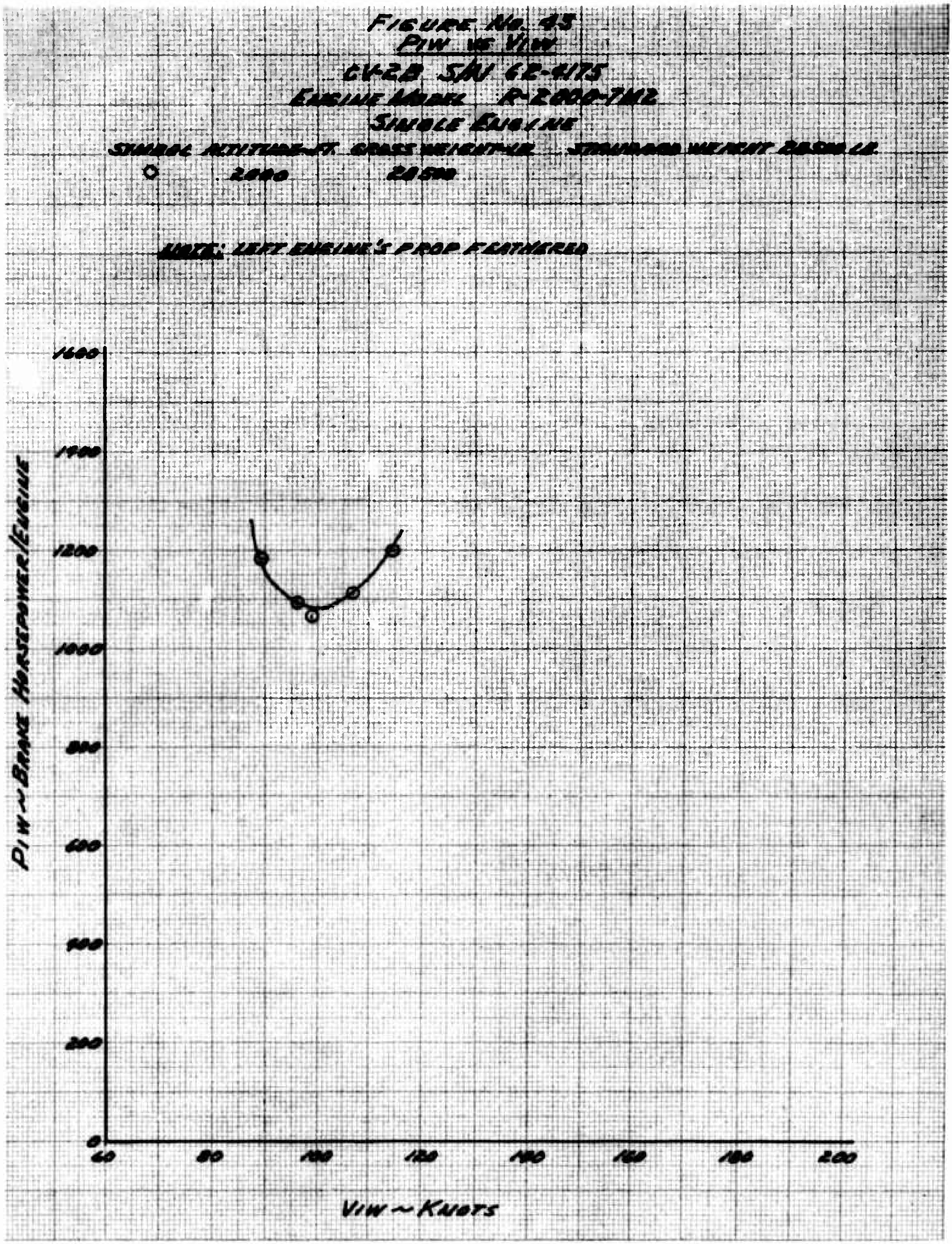


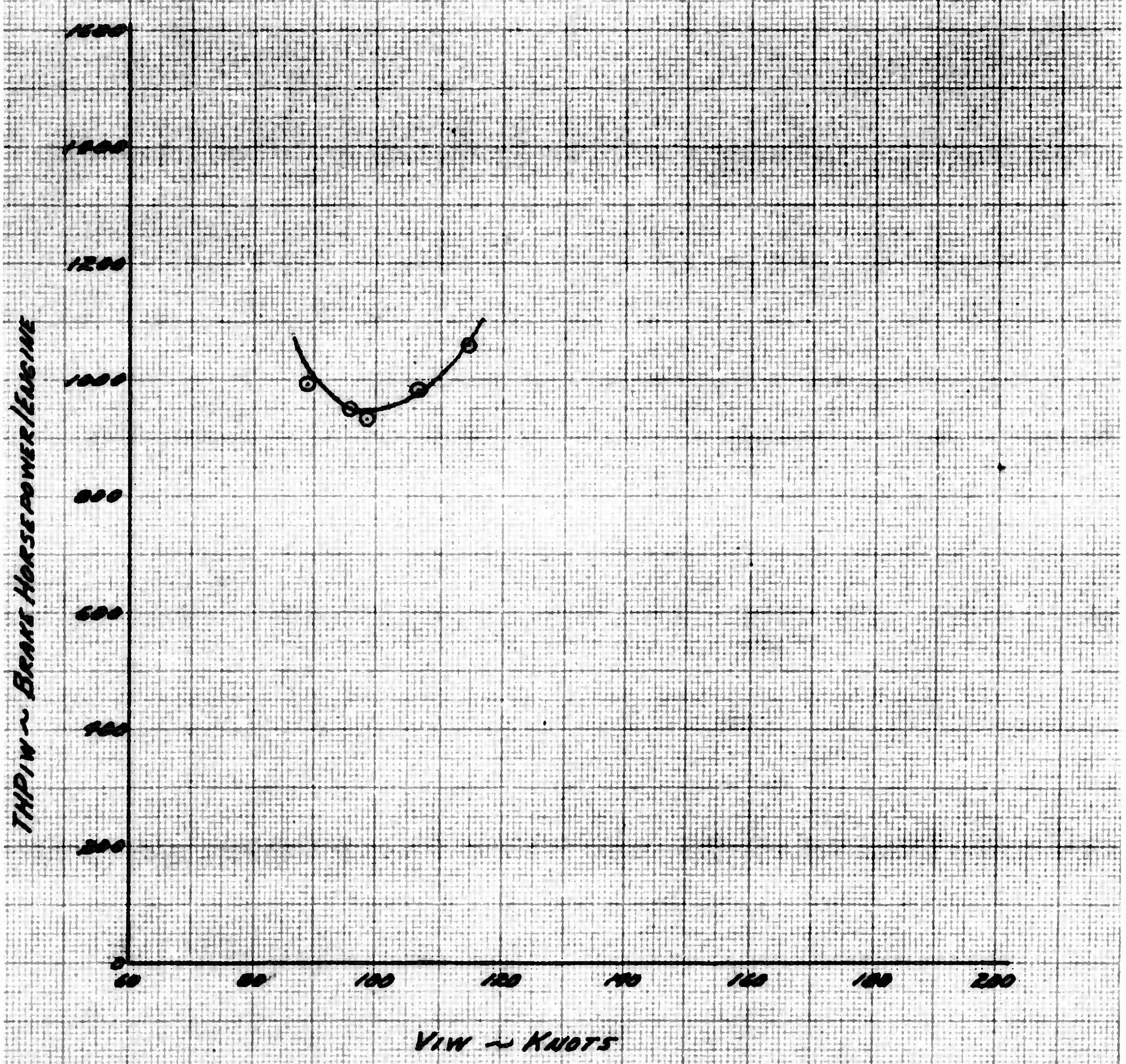
FIGURE NO. 45
PIW VS VIW
CV-2B S/N 62-4175
ENGINE MODEL R-2000-7M2
SINGLE ENGINE
SYMBOL ALTITUDE-FT. GROSS WEIGHT-LB. STANDARD WEIGHT 28500 LB.
2000 28500
NOTE: LEFT ENGINE'S PROP FEATHERED
1600
1400
1200
1000
800
600
400
200
0
PIW ~ BRAKE HORSEPOWER/ENGINE
60
80
100
120
140
160
180
200
VIW ~ KNOTS

FIGURE NO. 46
THPIW VS. VIW

CV-2B S/N 62-4175
ENGINE MODEL R-2000-7M2
SINGLE ENGINE

| SYMBOL | ALTITUDE~FT. | GROSS WEIGHT~LB. | STANDARD WEIGHT 28500 LB. |
|---|---|---|---|
| O | 2000 | 28500 | |

NOTE: LEFT ENGINE'S PROP FEATHERED



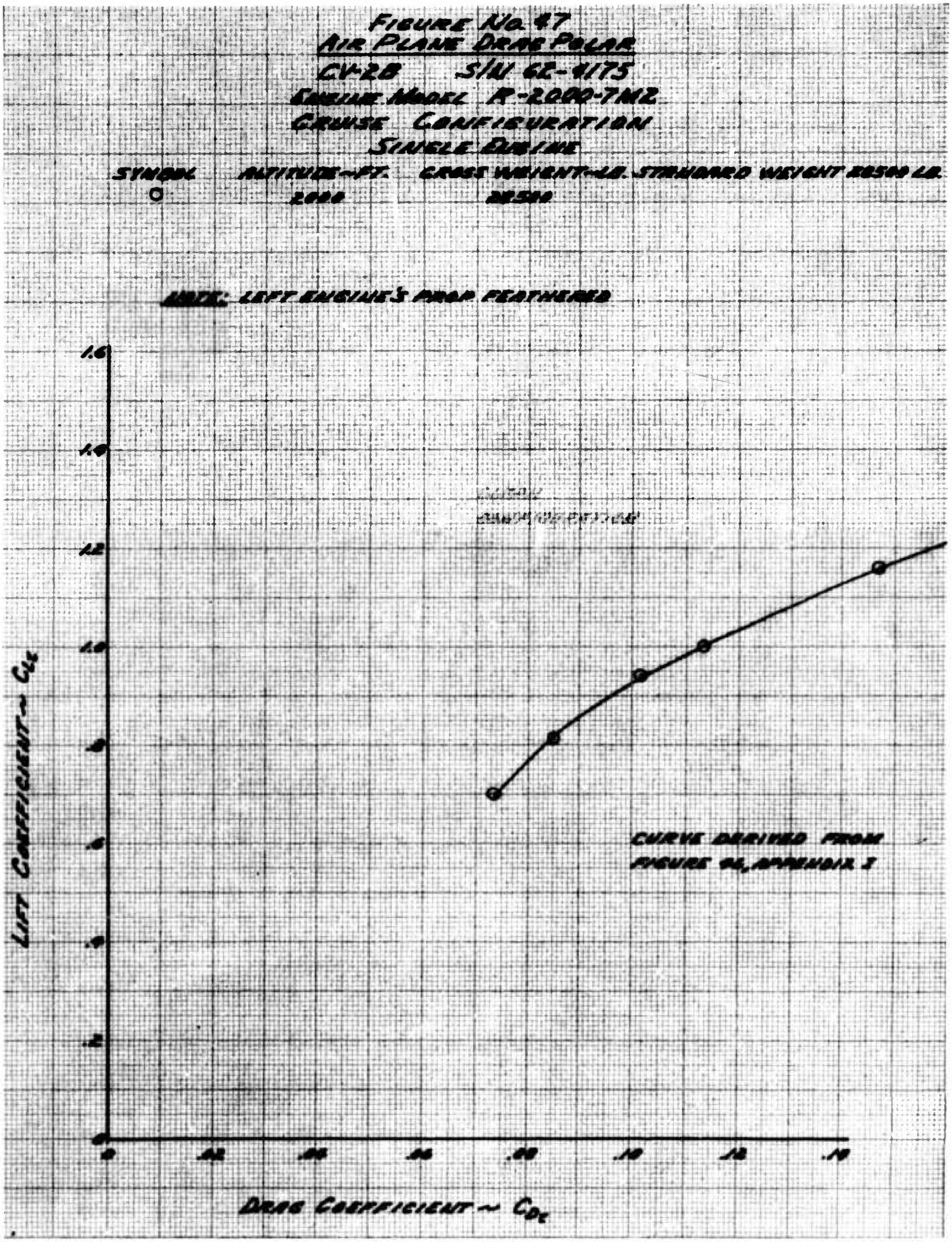


FIGURE NO. 47
AIR PLANE DRAG POLAR
CV-2B S/N 62-4175
ENGINE MODEL R-2000-7M2
CRUISE CONFIGURATION
SINGLE ENGINE
SYMBOL ALTITUDE~FT. GROSS WEIGHT~LB. STANDARD WEIGHT 28500 LB.
2000 28500
NOTE: LEFT ENGINE'S PROP FEATHERED
CURVE DERIVED FROM FIGURE 46, APPENDIX I
LIFT COEFFICIENT ~ $C_{LE}$
DRAG COEFFICIENT ~ $C_{DE}$

FIGURE No. 48

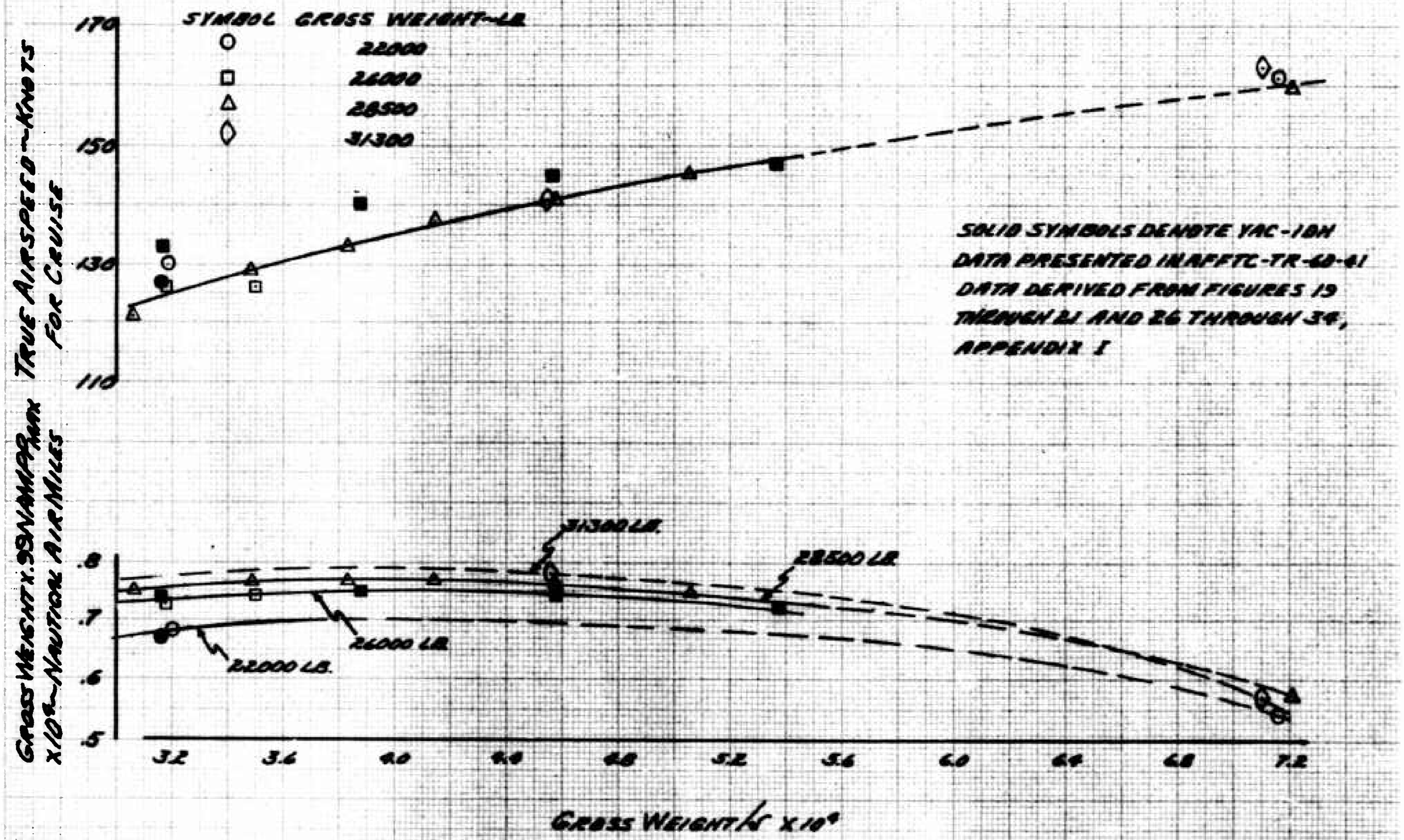
RANGE SUMMARY

CV-2B S/N 62-4175

ENGINE MODEL R-2000 - 7M2

BENDIX PD-12F-13A CARBURETOR

CRUISE CONFIGURATION



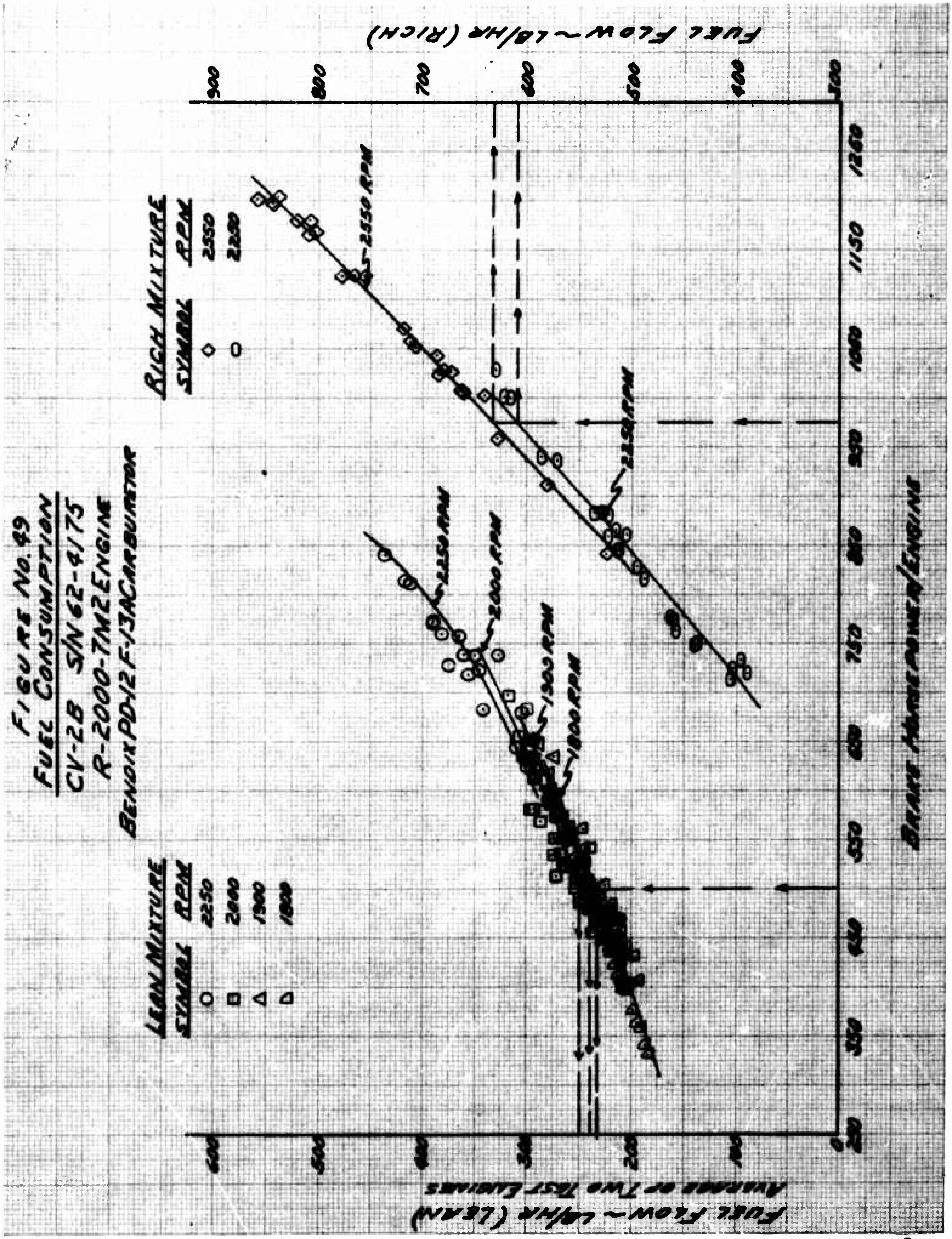


FIGURE NO. 49
FUEL CONSUMPTION
CV-2B S/N 62-4175
R-2000-7M2 ENGINE
BENDIX PD-12F-13A CARBURETOR
LEAN MIXTURE
SYMBOL RPM
2250
2000
1900
1800
RICH MIXTURE
SYMBOL RPM
2550
2250
2550 RPM
2250 RPM
2250 RPM
2000 RPM
1900 RPM
1800 RPM
FUEL FLOW ~ LB/HR (RICH)
FUEL FLOW ~ LB/HR (LEAN)
AVERAGE OF TWO TEST ENGINES
BRAKE HORSEPOWER/ENGINE

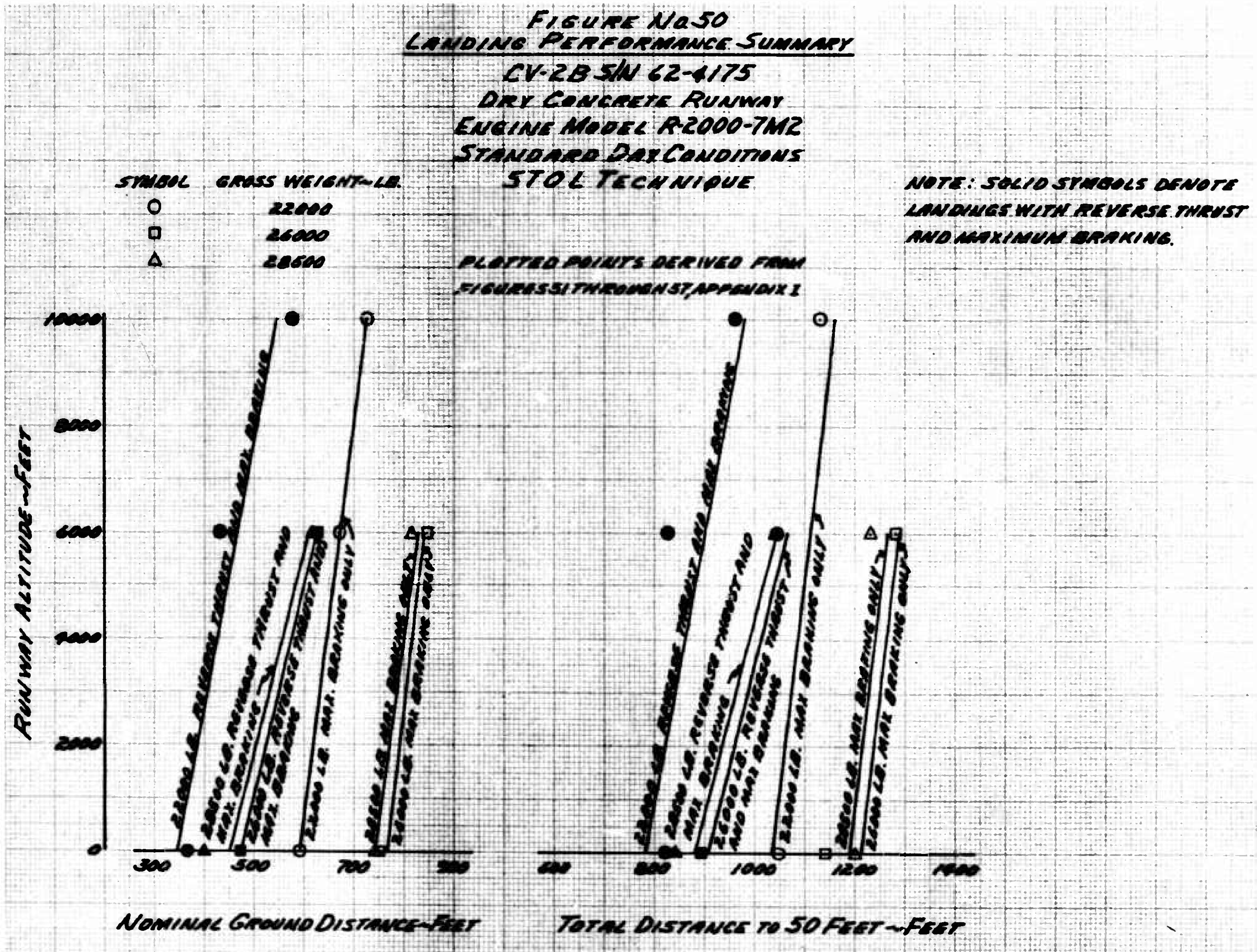


FIGURE NO 50
LANDING PERFORMANCE SUMMARY
CV-2B S/N 62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
STANDARD DAY CONDITIONS
STOL TECHNIQUE
SYMBOL GROSS WEIGHT~LB.
22000
26000
28500
PLOTTED POINTS DERIVED FROM FIGURES 51 THROUGH 57, APPENDIX I
NOTE: SOLID SYMBOLS DENOTE LANDINGS WITH REVERSE THRUST AND MAXIMUM BRAKING.
22000 LB. REVERSE THRUST AND MAX. BRAKING
26000 LB. REVERSE THRUST AND MAX. BRAKING
22000 LB. MAX. BRAKING ONLY
RUNWAY ALTITUDE~FEET
10000
8000
6000
4000
2000
0
300
500
700
900
1000
1200
NOMINAL GROUND DISTANCE~FEET
TOTAL DISTANCE TO 50 FEET~FEET

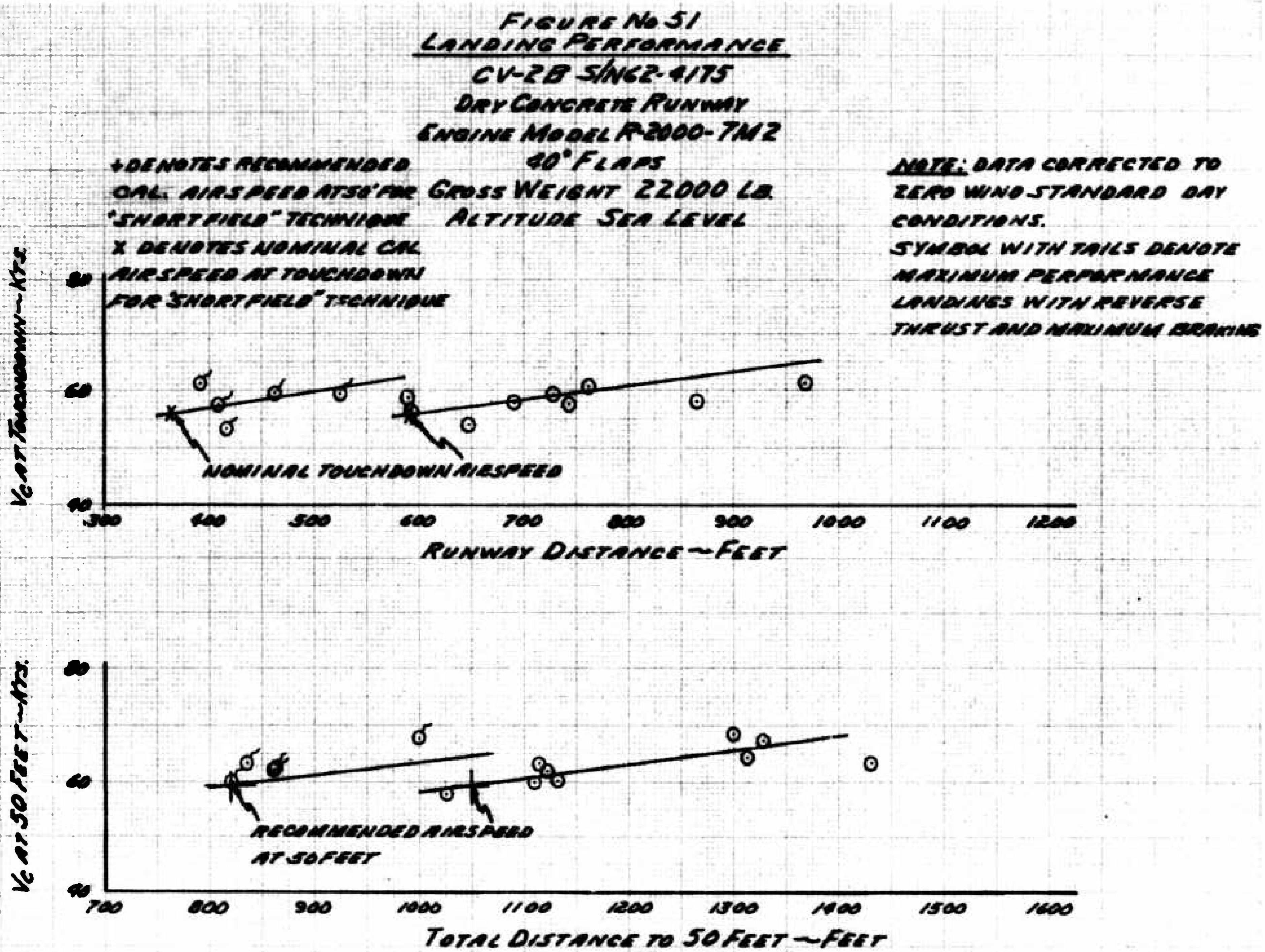


FIGURE No 51
LANDING PERFORMANCE
CV-2B S/N62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
40° FLAPS
GROSS WEIGHT 22000 LB.
ALTITUDE SEA LEVEL
+ DENOTES RECOMMENDED CAL. AIRSPEED AT 50' FOR "SHORT FIELD" TECHNIQUE
X DENOTES NOMINAL CAL. AIRSPEED AT TOUCHDOWN FOR "SHORT FIELD" TECHNIQUE
NOTE: DATA CORRECTED TO ZERO WIND-STANDARD DAY CONDITIONS.
SYMBOL WITH TAILS DENOTE MAXIMUM PERFORMANCE LANDINGS WITH REVERSE THRUST AND MAXIMUM BRAKING
NOMINAL TOUCHDOWN AIRSPEED
$V_C$ AT TOUCHDOWN ~ KTS.
80
60
40
300
400
500
600
700
800
900
1000
1100
1200
RUNWAY DISTANCE ~ FEET
RECOMMENDED AIRSPEED AT 50 FEET
$V_C$ AT 50 FEET ~ KTS.
80
60
40
700
800
900
1000
1100
1200
1300
1400
1500
1600
TOTAL DISTANCE TO 50 FEET ~ FEET

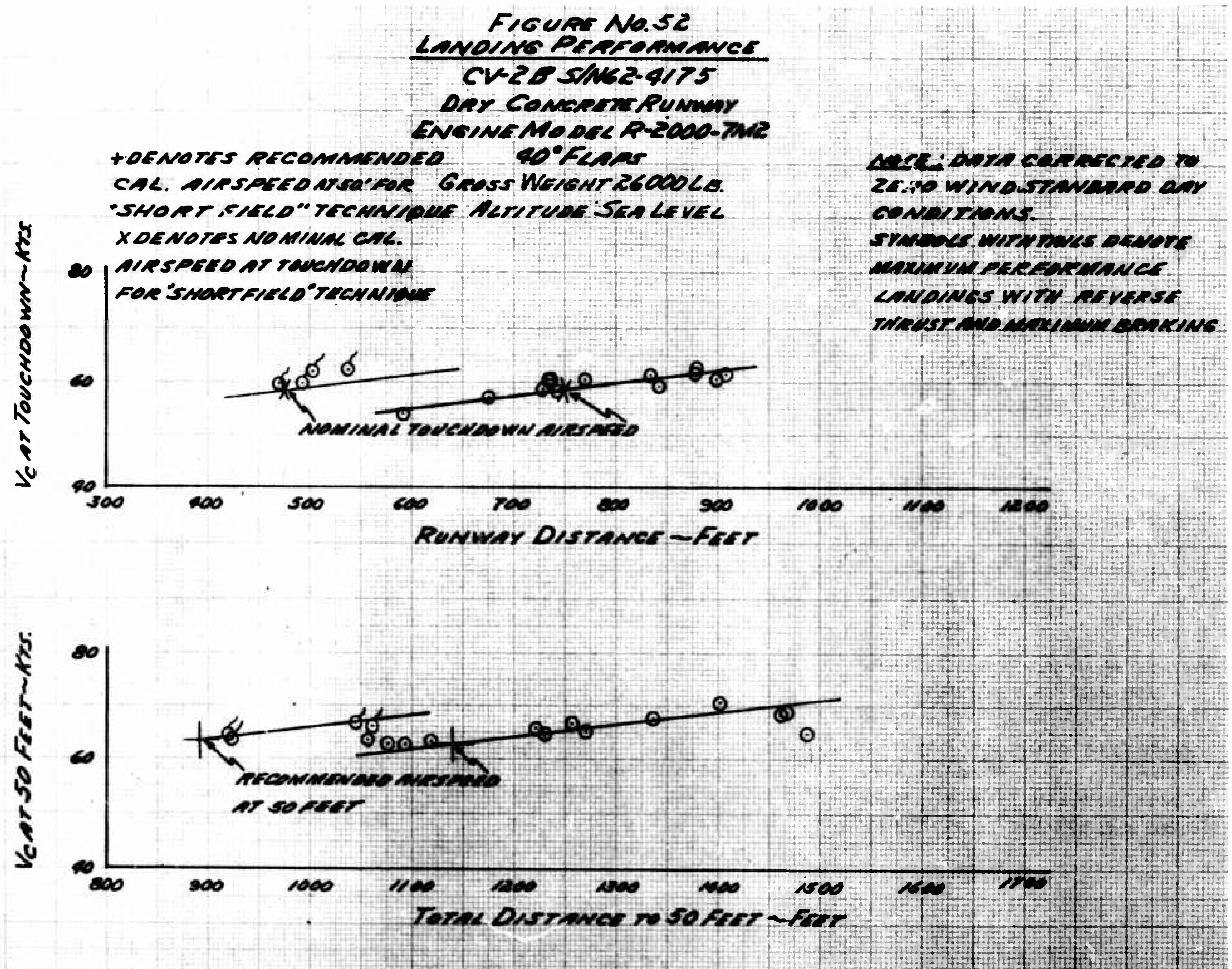


FIGURE No. 52
LANDING PERFORMANCE
CV-2B S/N62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
40° FLAPS
GROSS WEIGHT 26000 LB.
ALTITUDE SEA LEVEL
+DENOTES RECOMMENDED CAL. AIRSPEED AT 50' FOR "SHORT FIELD" TECHNIQUE
X DENOTES NOMINAL CAL. AIRSPEED AT TOUCHDOWN FOR "SHORT FIELD" TECHNIQUE
NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS.
SYMBOLS WITH TAILS DENOTE MAXIMUM PERFORMANCE LANDINGS WITH REVERSE THRUST AND MAXIMUM BRAKING
NOMINAL TOUCHDOWN AIRSPEED
$V_C$ AT TOUCHDOWN ~ KTS.
80
60
40
300
400
500
600
700
800
900
1000
1100
1200
RUNWAY DISTANCE ~ FEET
RECOMMENDED AIRSPEED AT 50 FEET
$V_C$ AT 50 FEET ~ KTS.
80
60
40
800
900
1000
1100
1200
1300
1400
1500
1600
1700
TOTAL DISTANCE TO 50 FEET ~ FEET

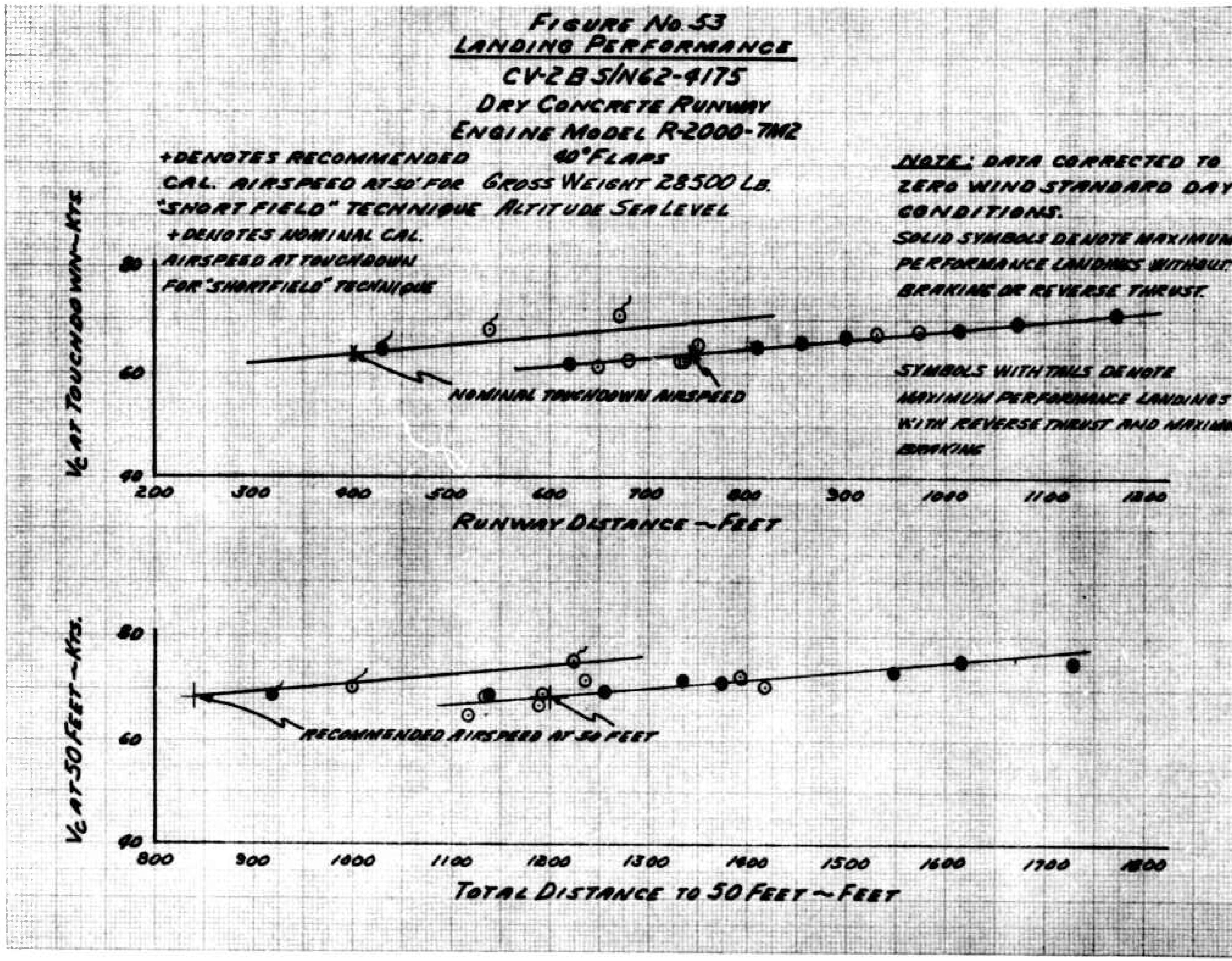


FIGURE NO. 53
LANDING PERFORMANCE
CV-2B S/N62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
40° FLAPS
GROSS WEIGHT 28500 LB.
ALTITUDE SEA LEVEL
+ DENOTES RECOMMENDED CAL. AIRSPEED AT 50' FOR "SHORT FIELD" TECHNIQUE
+ DENOTES NOMINAL CAL. AIRSPEED AT TOUCHDOWN FOR "SHORTFIELD" TECHNIQUE
NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS.
SOLID SYMBOLS DENOTE MAXIMUM PERFORMANCE LANDINGS WITHOUT BRAKING OR REVERSE THRUST.
SYMBOLS WITH TAILS DENOTE MAXIMUM PERFORMANCE LANDINGS WITH REVERSE THRUST AND MAXIMUM BRAKING
NOMINAL TOUCHDOWN AIRSPEED
$V_C$ AT TOUCHDOWN ~ KTS
80
60
40
200
300
400
500
600
700
800
900
1000
1100
1200
RUNWAY DISTANCE ~ FEET
RECOMMENDED AIRSPEED AT 50 FEET
$V_C$ AT 50 FEET ~ KTS.
80
60
40
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
TOTAL DISTANCE TO 50 FEET ~ FEET

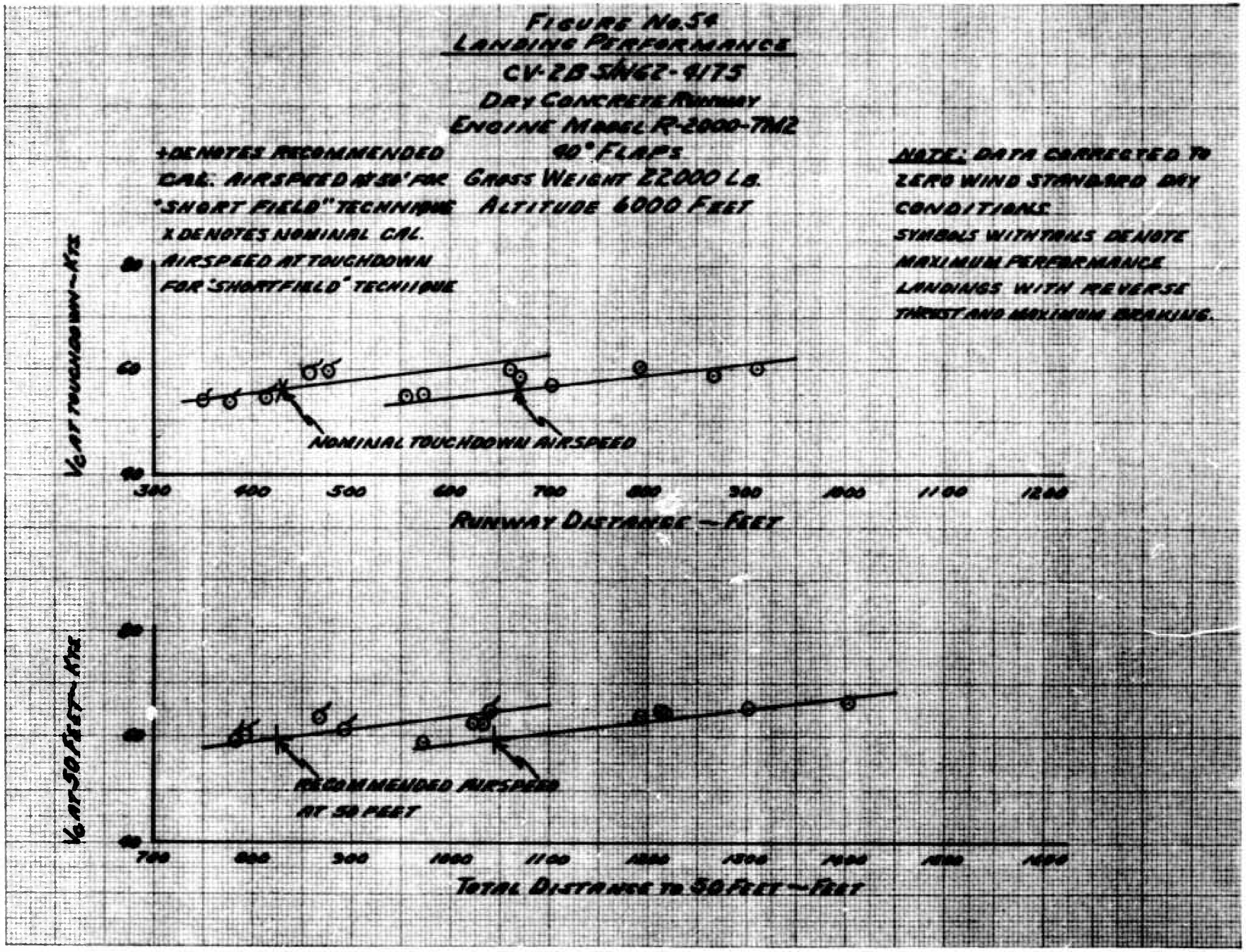


FIGURE No. 54
LANDING PERFORMANCE
CV-2B S/N 62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
40° FLAPS
GROSS WEIGHT 22000 LB.
ALTITUDE 6000 FEET
+ DENOTES RECOMMENDED
CAL. AIRSPEED AT 50' FOR
"SHORT FIELD" TECHNIQUE
X DENOTES NOMINAL CAL.
AIRSPEED AT TOUCHDOWN
FOR "SHORTFIELD" TECHNIQUE
NOTE: DATA CORRECTED TO
ZERO WIND STANDARD DAY
CONDITIONS.
SYMBOLS WITH TAILS DENOTE
MAXIMUM PERFORMANCE
LANDINGS WITH REVERSE
THRUST AND MAXIMUM BRAKING.
$V_c$ AT TOUCHDOWN ~ KTS
80
60
40
NOMINAL TOUCHDOWN AIRSPEED
300
400
500
600
700
800
900
1000
1100
1200
RUNWAY DISTANCE ~ FEET
$V_c$ AT 50 FEET ~ KTS
80
60
40
RECOMMENDED AIRSPEED
AT 50 FEET
700
800
900
1000
1100
1200
1300
1400
1500
1600
TOTAL DISTANCE TO 50 FEET ~ FEET

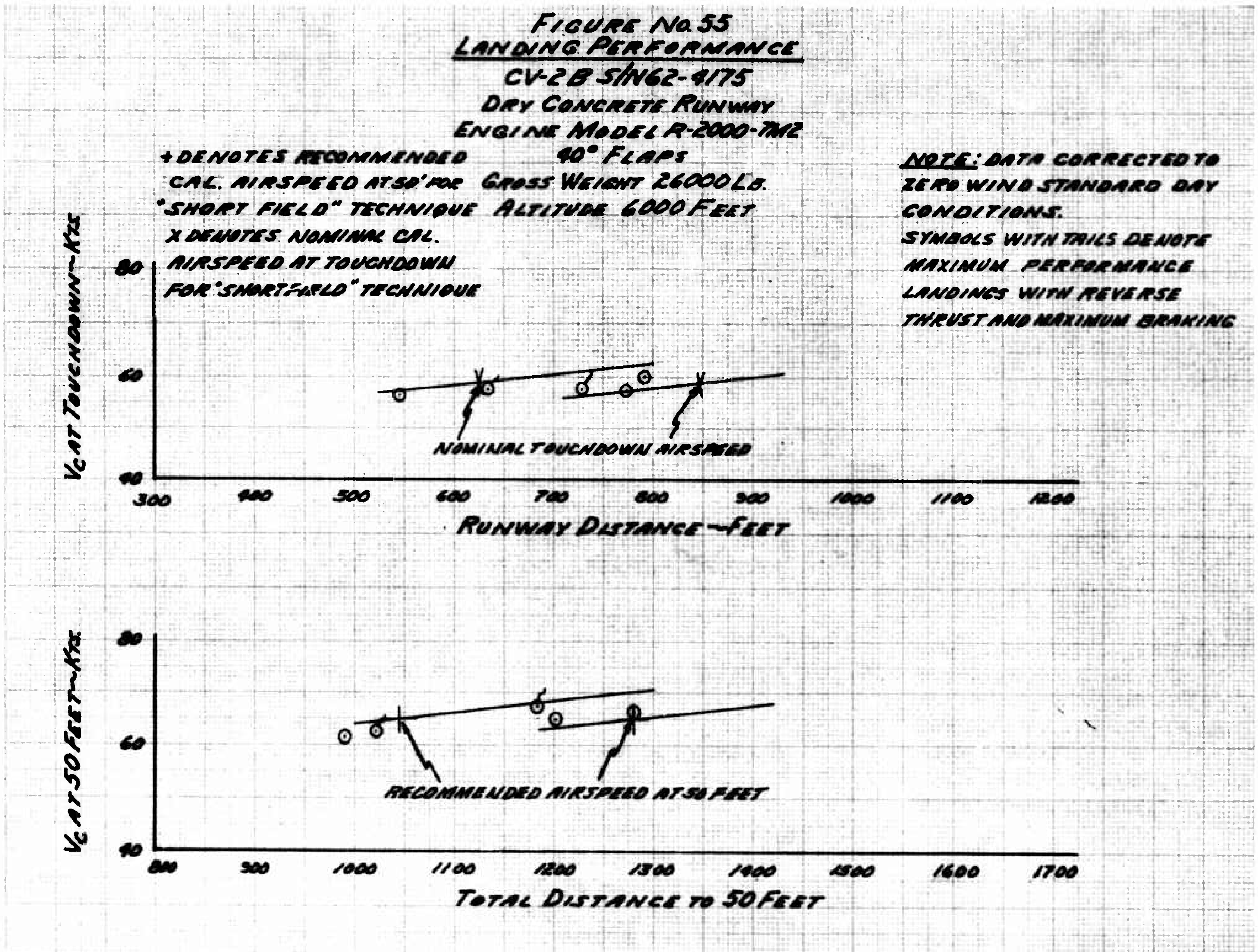
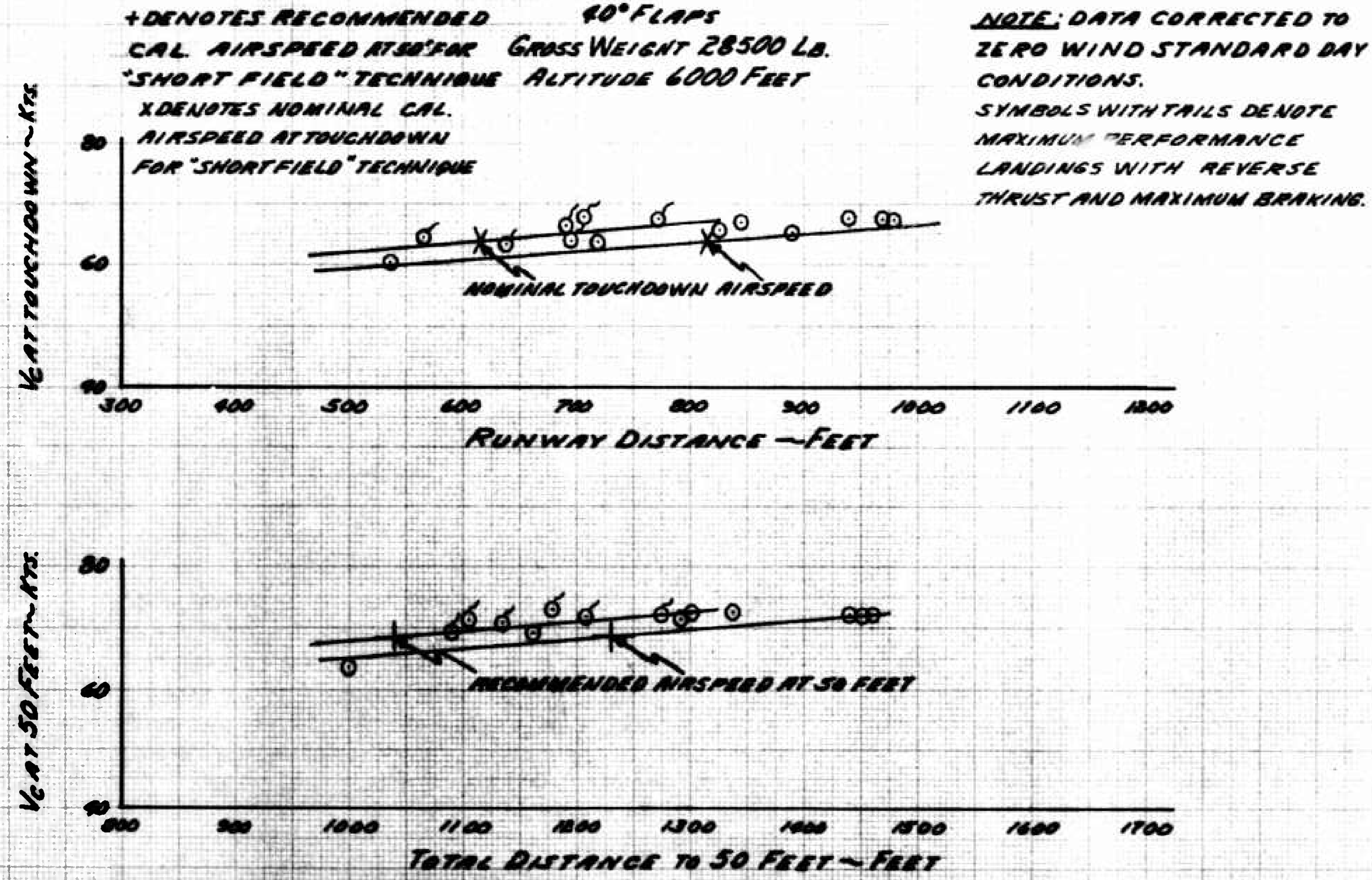


FIGURE No. 55
LANDING PERFORMANCE
CV-2B S/N62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2
40° FLAPS
GROSS WEIGHT 26000 LB.
ALTITUDE 6000 FEET
+ DENOTES RECOMMENDED CAL. AIRSPEED AT 50' FOR "SHORT FIELD" TECHNIQUE
X DENOTES NOMINAL CAL. AIRSPEED AT TOUCHDOWN FOR "SHORTFIELD" TECHNIQUE
NOTE: DATA CORRECTED TO ZERO WIND STANDARD DAY CONDITIONS.
SYMBOLS WITH TAILS DENOTE MAXIMUM PERFORMANCE LANDINGS WITH REVERSE THRUST AND MAXIMUM BRAKING
NOMINAL TOUCHDOWN AIRSPEED
$V_C$ AT TOUCHDOWN ~ KTS
80
60
40
300
400
500
600
700
800
900
1000
1100
1200
RUNWAY DISTANCE ~ FEET
RECOMMENDED AIRSPEED AT 50 FEET
$V_C$ AT 50 FEET ~ KTS
80
60
40
800
900
1000
1100
1200
1300
1400
1500
1600
1700
TOTAL DISTANCE TO 50 FEET

Figure No. 56
LANDING PERFORMANCE
CV-2B S/N62-4175
DRY CONCRETE RUNWAY
ENGINE MODEL R-2000-7M2



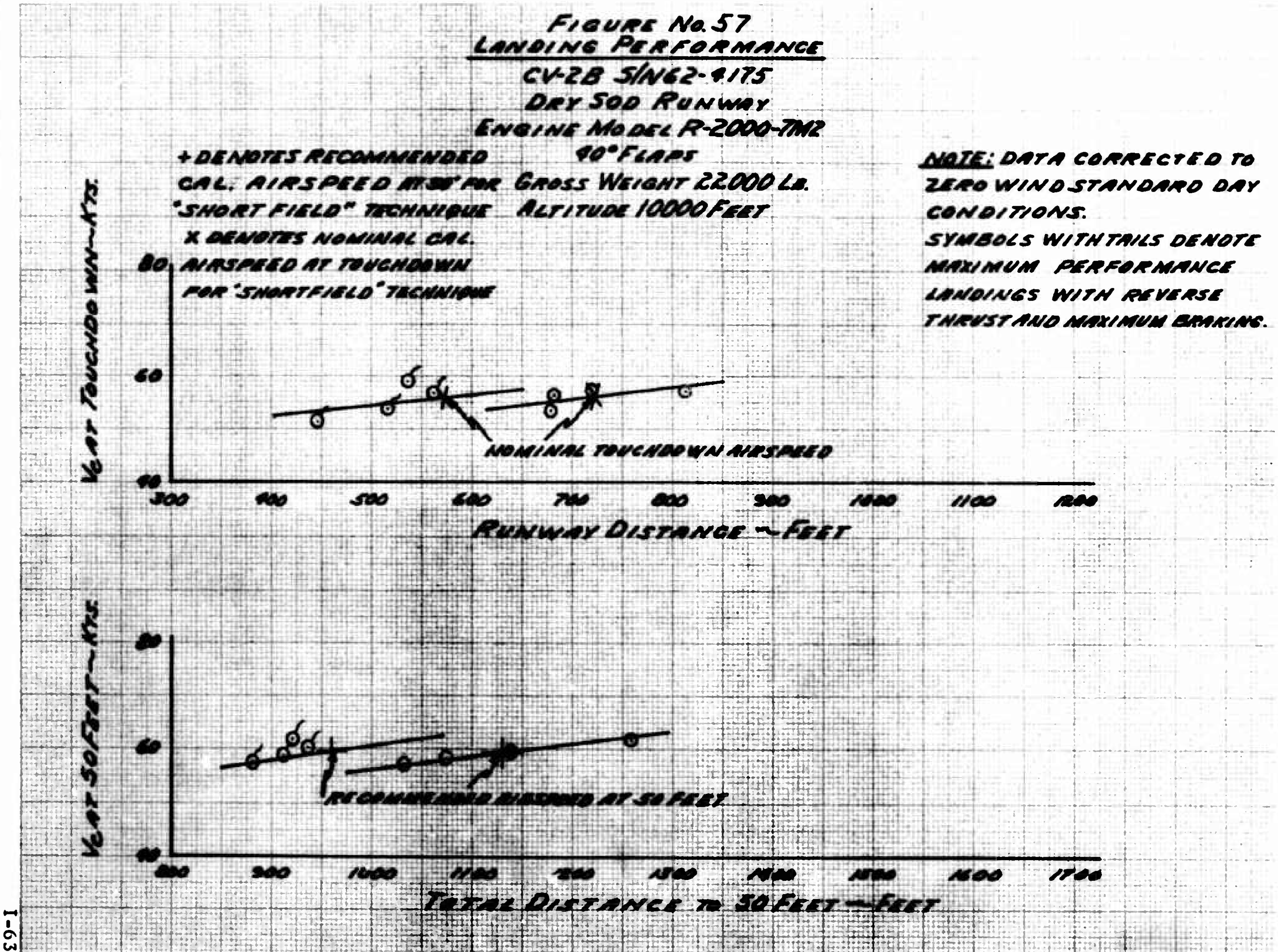


FIGURE No. 57
LANDING PERFORMANCE
CV-2B S/N62-4175
DRY SOD RUNWAY
ENGINE MODEL R-2000-7M2
40° FLAPS
GROSS WEIGHT 22000 LB.
ALTITUDE 10000 FEET
+ DENOTES RECOMMENDED
CAL. AIRSPEED AT 50' FOR
"SHORT FIELD" TECHNIQUE
X DENOTES NOMINAL CAL.
AIRSPEED AT TOUCHDOWN
FOR "SHORTFIELD" TECHNIQUE
NOTE: DATA CORRECTED TO
ZERO WIND STANDARD DAY
CONDITIONS.
SYMBOLS WITH TAILS DENOTE
MAXIMUM PERFORMANCE
LANDINGS WITH REVERSE
THRUST AND MAXIMUM BRAKING.
V_CAL TOUCHDOWN ~ KTS.
80
60
40
300
400
500
600
700
800
900
1000
1100
1200
NOMINAL TOUCHDOWN AIRSPEED
RUNWAY DISTANCE ~ FEET
V_CAL 50 FEET ~ KTS.
80
60
40
1700
RECOMMENDED AIRSPEED AT 50 FEET
TOTAL DISTANCE TO 50 FEET ~ FEET

FIGURE No. 58

Δ BRAKE HORSEPOWER VS CALIBRATED AIRSPEED

CV-2B S/N 62-4175

ENGINE MODEL R-2000-7M2

CARBURETOR AIR COLD

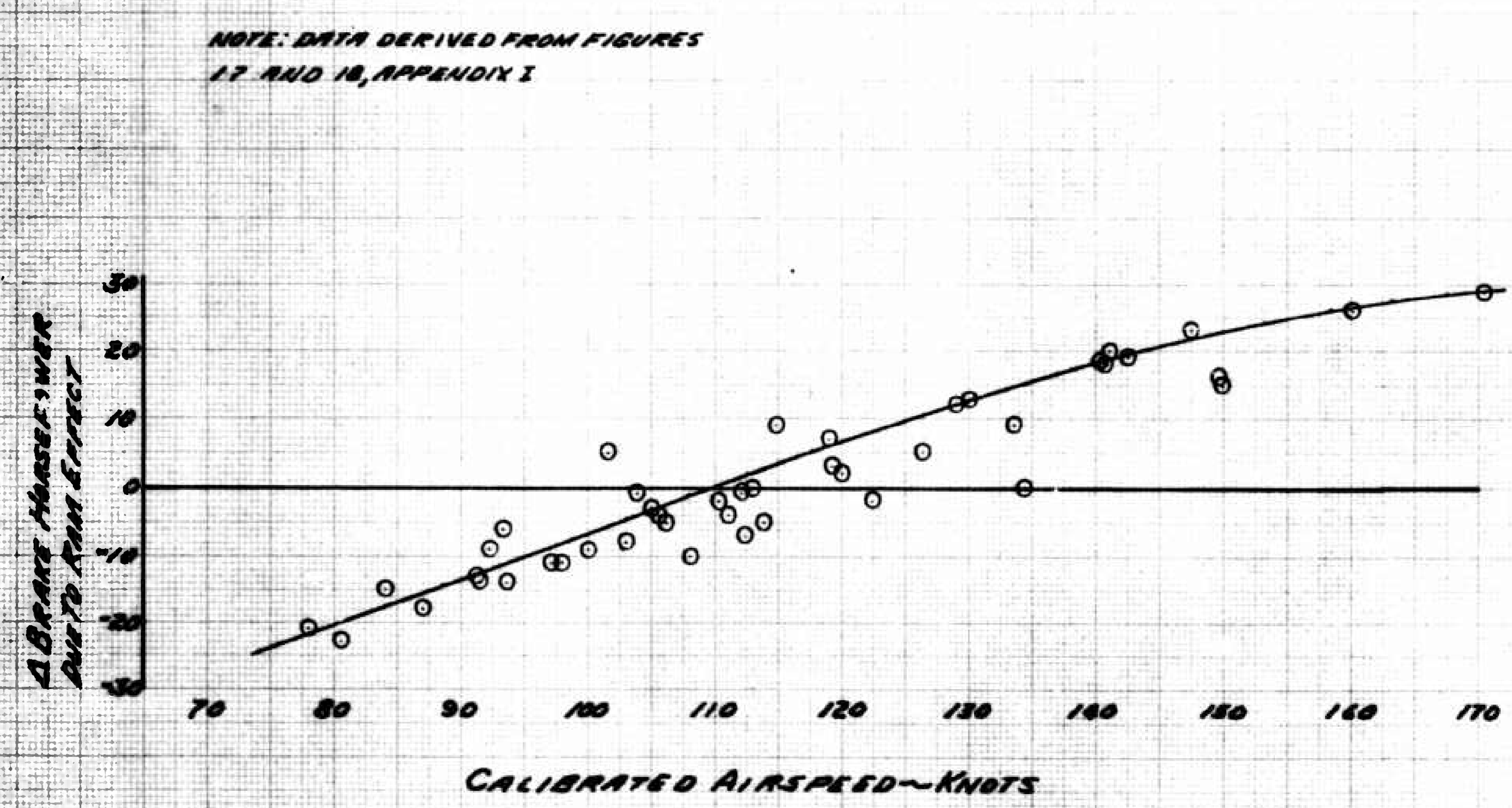


FIGURE No. 59
AIRSPEED CALIBRATION
CV-2B S/N62-4175
STANDARD SHIP'S SYSTEM

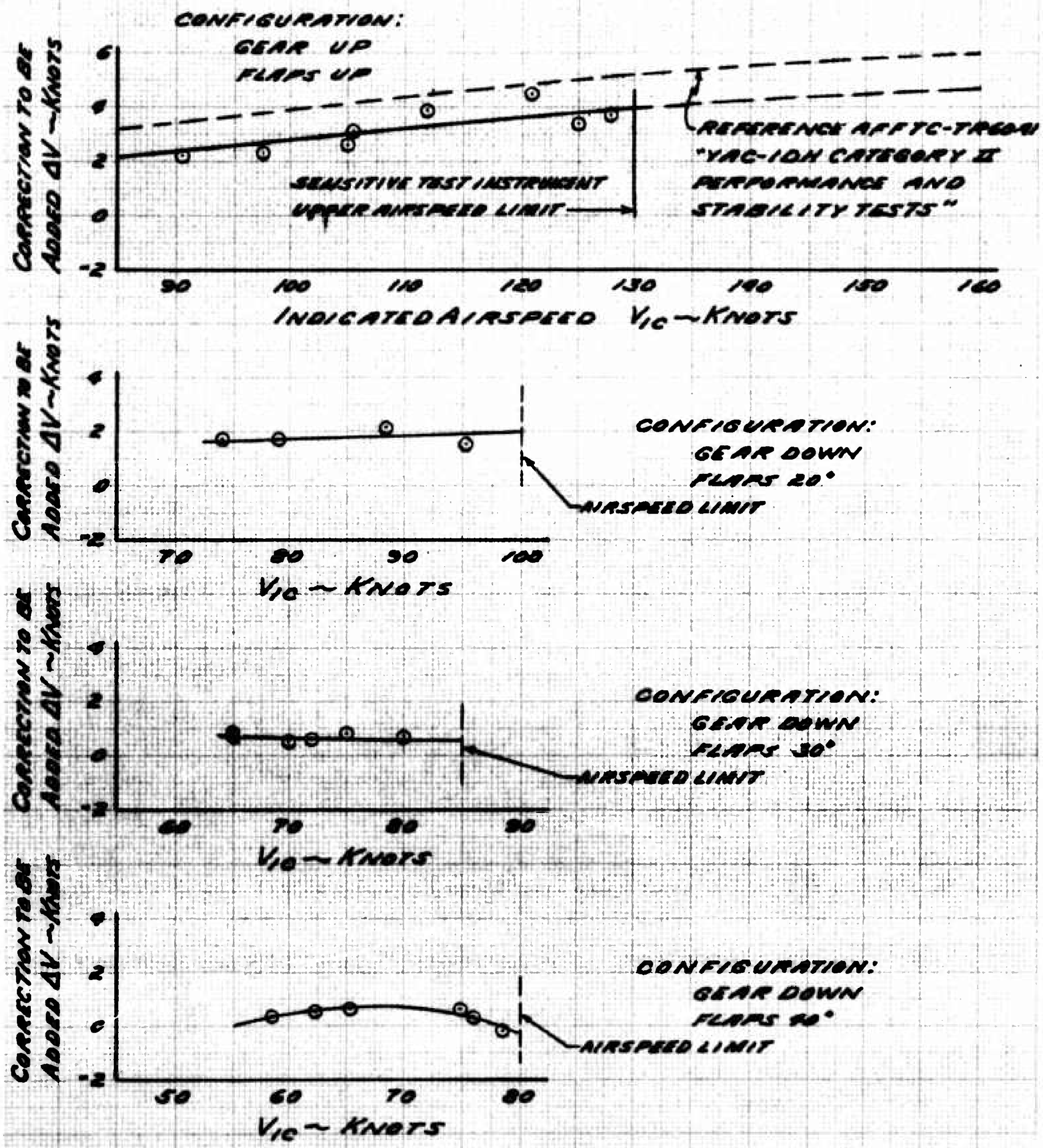
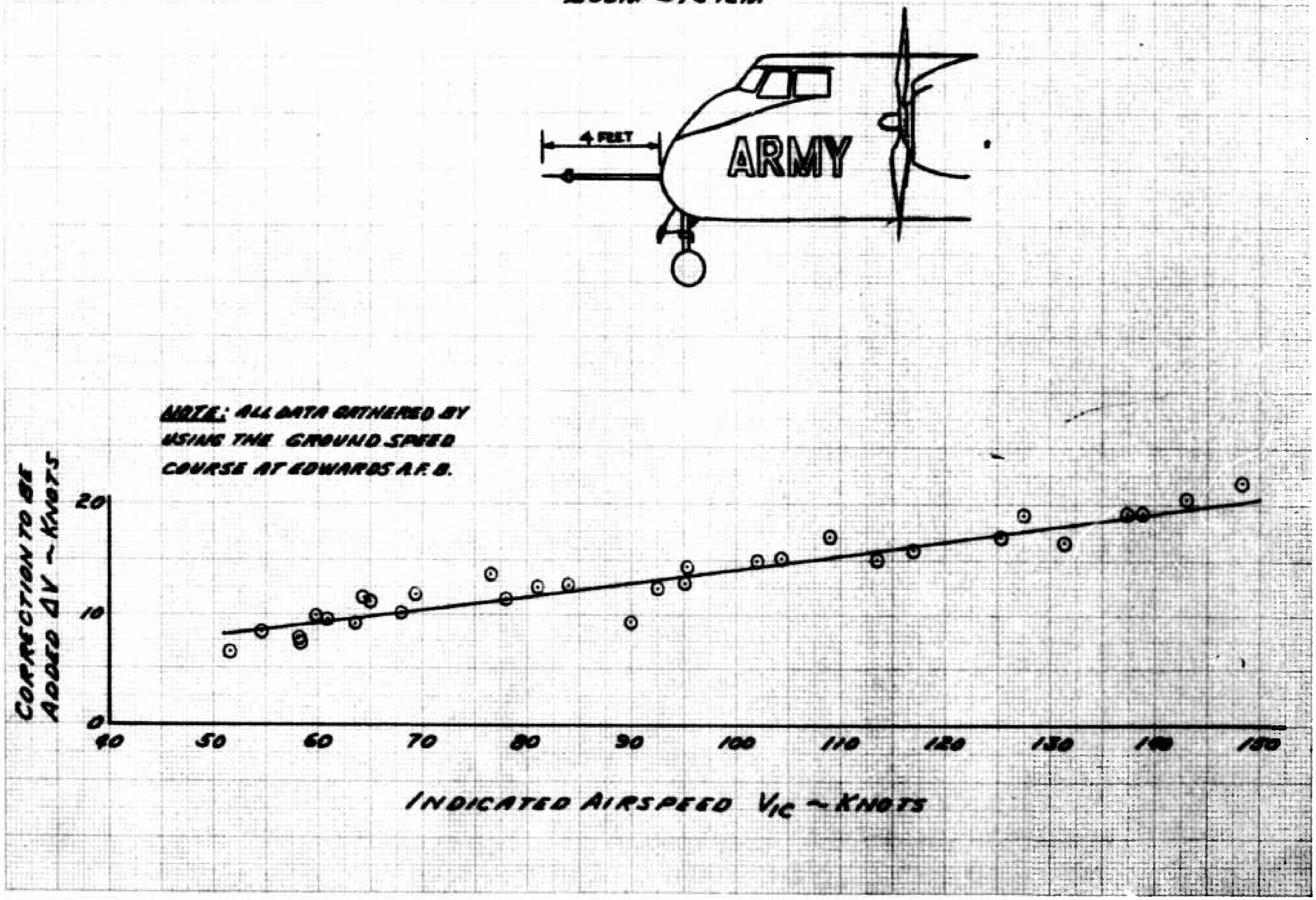


FIGURE NO. 60

AIRSPEED CALIBRATION

CV-2B S/N62-4175

BOOM SYSTEM



# Appendix II

## DATA ANALYSIS METHODS

### 1.0 NOMENCLATURE

| Symbol | Description | Units |
|---|---|---|
| S | Wing Area | sq ft |
| c | Chord Width | ft |
| MAC | Mean Aerodynamic Chord Width | ft |
| b | Wing Span | ft |
| e | Airplane Efficiency | -- |
| AR | Aspect Ratio = $\frac{b}{c}$ | -- |
| BHP | Brake Horsepower | $\frac{\text{ft-lb}}{\text{min}} \times \frac{1}{33{,}000}$ |
| BHP | Chart Brake Horsepower (Reference 1.1.h) | $\frac{\text{ft-lb}}{\text{min}} \times \frac{1}{33{,}000}$ |
| THP | Thrust Horsepower | $\frac{\text{ft-lb}}{\text{min}} \times \frac{1}{33{,}000}$ |
| CAT | Carburetor Air Temperature | °K, °C |
| $C_l$ | Lift Coefficient | -- |
| $C_d$ | Drag Coefficient | -- |
| $C_p$ | Power Coefficient of Propeller | -- |
| $C_t$ | Thrust Coefficient of Propeller | -- |
| C.G. | Center of Gravity | % of MAC |
| dH/dt | Rate of Change of Pressure Altitude | ft/min |
| H | Altitude | ft |
| MPA | Maximum Power Available | BHP |

| | | |
|---|---|---|
| J | Propeller Activity Factor | -- |
| MAP | Absolute Manifold Pressure | in. Hg |
| M | Mach Number | -- |
| $P_a$ | Atmospheric Pressure | in. Hg |
| RPM | Engine RPM | revolutions/min |
| $R/C_s$ | Standard Day Rate of Climb = $R/C_t + \Delta R/C_{hp} + \Delta\ R/C_w + \Delta\ R/C_{induced}$ | ft/min |
| $R/C_t$ | Test Day Tape Line Rate of Climb = $dH/dt \times \sqrt{T_{a_t}/T_{a_s}}$ | ft/min |
| $T_a$ | Ambient Temperature | °K, °C |
| $V_c$ | Calibrated Airspeed | Kt |
| $V_t$ | True Airspeed $V_c/\sqrt{\sigma}$ | Kt |
| W | Aircraft Gross Weight | lb |
| $W_f$ | Fuel Flow | lb/hr |
| $\Delta$ BHP | The change in power between test day and standard day, $BHP_s - BHP_t$ | $\frac{ft\text{-}lb}{min} \times \frac{1}{33,000}$ |
| $\Delta\ R/C_{hp}$ | Increment of change to $R/C_t$ because of change in power from test to standard day | |
| | $R/C_{hp} = \Delta\ BHP \times 33,000/W$ | ft/min |
| $\Delta R/C_w$ | Increment of change to R/C because of change in gross weight from standard gross weight | |
| | $\Delta\ R/C_w = BHP \times 33,000 \left( \frac{1}{W_s} - \frac{1}{W_t} \right)$ | ft/min |

| | | |
|---|---|---|
| $R/C_{induced}$ | Increment of change to R/C because of changed induced drag $R/C_{induced} = \frac{50.65 \; T_{a_s} \times W}{P_a \, M \, b^2 \, e}$ | ft/min |
| NAMPP | Nautical Air Mile Per Pound of Fuel | -- |
| BSFC | Brake Specific Fuel Comsumption | lb/hr/BHP |
| $\delta$ | Pressure Ratio = $\frac{P_a}{29.92}$ | -- |
| $\eta$ | Propeller Efficiency Factor | -- |
| $\rho$ | Air Density | slug/ft$^3$ |
| $\sigma$ | Air Density Ratio = t/.002378 | -- |

**Subscripts**

| | |
|---|---|
| t | Test conditions |
| s | Standard conditions |
| a | Ambient |
| p | Pressure |
| d | Density |
| w | Weight |

## 2.0 GENERAL

The equations and analysis methods used to reduce the performance data of the CV-2B airplane are briefly outlined in this paragraph.

The engines used in this test program were uncalibrated and had zero usage time. Brake horsepower was, therefore, determined by using the engine manufacturer's power chart (Reference 1.1.h).

The test data revealed that the carburetor air temperature (CAT) rise was 2 degrees Centigrade (C) for all flight conditions at all altitudes.

Test brake horsepower ($BHP_t$) was determined by correcting the chart brake horsepower for carburetor air temperature rise as follows:

$$BHP_t = BHP_c \sqrt{\frac{T_{a_s}}{CAT_t}}$$

WHERE

$BHP_t$ = Test brake horsepower

$BHP_c$ = Chart brake horsepower determined from test manifold pressure, rpm, pressure altitude, and the engine manufacturer's power chart.

$T_{a_s}$ = Standard temperature at test pressure altitude, degrees K.

$CAT_t$ = Test carburetor air temperature, degrees K.

## 2.1 POWER AVAILABLE

Power available values used in calculating performance data were obtained from a faired curve of power available versus standard altitude for check climbs and calibrated airspeed for sawtooth climbs.

$$BHP_a = BHP_{ta} \sqrt{\frac{CAT_t}{T_{a_s} + (CAT_t - T_{a_t})}}$$

## 2.2 HUMIDITY CORRECTION

A humidity correction was applied to all performance data where applicable.

$$BHP_t = BHP_{ta} \left[ 1 - K_1 \frac{200_e}{P_a} \right]$$

WHERE

$BHP_t$ = Test brake horsepower

$1 - K_1 \frac{200_e}{P_a}$ = Humidity correction factor

$K_1 = \frac{\text{Humidity Loss Assumed}}{\text{Humidity Loss Possible}}$

Assumed to be .5

e = Partial pressure of the water vapor in air

$P_a$ = Ambient Air Pressure

## 3.0 TAKEOFF

STOL takeoff tests were conducted utilizing takeoff power (1450 horsepower per engine to critical altitude and full throttle thereafter). All engine power paramenters were recorded in the static condition just prior to brake release.

The gross weight, C.G., and engine power output were held constant and the yoke-pull airspeed was varied for each takeoff conducted. Takeoff distances, true airspeed at lift-off and 50-foot data were recorded with a Fairchild Flight Analyzer.

Takeoff data were corrected to standard-day, no-wind, level-runway conditions, using the methods developed in References 1.1.i and 1.1.j.

## 4.0 CLIMBS

### 4.1 CHECK CLIMBS

Check climbs were flown using a climb schedule developed from the sawtooth climbs.

The observed rate of climb was corrected to tabeline values by using the following equation:

$$R/C_t = \frac{dHP}{dt}\sqrt{\frac{T_{a_t}}{T_{a_s}}}$$

Power correction to standard conditions was made by using the following equation:

$$\Delta\ R/C_{hp} = \frac{BHP \times 33{,}000}{W_t}$$

Weight corrections were made by using the following equation:

$$\Delta\ R/C_w = BHP \times 33{,}000\ \left(\frac{1}{W_s} - \frac{1}{W_t}\right)$$

WHERE

$\Delta W = W_s - W_t$

Induced drag corrections were made by using the following equation:

$$\Delta\ R/C_{induced} = - \frac{50.65 \sqrt{T_a}_s \times \Delta W}{P_a\ M\ b^2\ e}$$

4.2 SAWTOOTH CLIMBS

Sawtooth climbs were conducted to determine the optimum climb schedules. These tests were reduced to standard-day conditions using the same methods outlined in Paragraph 4.1.

5.0 LEVEL FLIGHT

Level-flight speed power data were obtained at constant $W/\delta$ and corrected to standard conditions using the methods outlined in Reference 1.1.i.

6.0 Fuel flow data were collected during each level flight test. The power and fuel flow data were then reduced to standard-day conditions and presented as a function of brake horsepower and engine rpm.

Specific range, nautical air miles per pound (NAMPP), was determined by dividing true airspeed by the resulting fuel flow for each level flight point ($V_t/W_f$). Specific power, brake horsepower specific fuel consumption (BSFC), was determined by dividing fuel flow by brake horsepower for each level flight point $\left(\frac{W_f}{BHP}\right)$.

## 7.0 LANDINGS

STOL landing tests were conducted in conjunction with STOL takeoff tests. The same variables were controlled during these tests as were mentioned in the section entitled "TAKEOFF." The 50-foot airspeed was varied for each landing conducted. Landing distances, true airspeed for both 50-foot and touchdown, were recorded with a Fairchild Flight Analyzer.

Landing data were corrected to standard-day, zero-wind conditions using the methods outlined in References 1.1.i and 1.1.j. No weight correction was made.

## 8.0 CORRECTED POWER CURVES

$P_{iw}$ versus $V_{iw}$ curves for the test airplane were calculated from the level-flight test data. These data were corrected to 28,500 pounds at sea level.

$THP_{iw}$ versus $V_{iw}$ curves were calculated from the level-flight test data. These data were simply the $P_{iw}$ data converted to $THP_{iw}$.

$$P_{iw} = \frac{BHP\sqrt{\sigma}}{(W_t/W_s)^{3/2}}$$

$$THP_{iw} = P_{iw} \times \eta_p$$

$$V_{iw} = \frac{V\sqrt{\sigma}}{(W_t/W_s)^{1/2}}$$

## 9.0 AIRPLANE DRAG POLAR

Airplane drag polar curves were calculated from $THP_{iw}$ versus $V_{iw}$ curves and no jet augmentation effects were considered.

$$C_{lt} = \frac{W_t \times .3231}{V_{T_t}^2 \delta}$$

$$C_{p_t} = \frac{BHP_t \times 210.28}{V_{T_t}^2 \delta} \quad \text{(both engines operating)}$$

$$C_{p_t} = \frac{BHP_t \times 105.14}{V_{T_t}^2 \delta} \quad \text{(one engine operating)}$$

## 10.0 AIRSPEED POSITION ERROR CALIBRATION

The boom and standard systems were calibrated utilizing the ground speed course calibration method. All data were obtained for a gross weight range of 24,000 to 25,000 pounds for various flap settings.

# Appendix III

## GENERAL AIRCRAFT INFORMATION

1.0 DESCRIPTION OF AIRPLANE

The CV-2B is a medium-range, high-wing, all-metal cargo-type airplane whose tactical mission is transport of cargo and personnel, aerial delivery of troops and supplies, and use in medical evacuation. The test airplane was powered by two Pratt and Whitney Twin Wasp (R-2000-7M2) engines.

The test airplane is equipped with constant-speed, full-feathering and reversing Hamilton Standard propellers (Model 43D50-659).

1.1 DIMENSIONS AND DESIGN DATA

a. General

| | |
|---|---|
| (1) Span | 98 ft 1/2 in |
| (2) Height of vertical tail over static ground line | 31 ft 9 in |
| (3) Overall Length | 72 ft 7 in |
| (4) Track of main wheels | 23 ft 1-1/2 in |

b. Areas

| | |
|---|---|
| (1) Wing area, total, including ailerons, flaps, and 94 sq ft of fuselage | 912 sq ft |
| (2) Wing trailing edge flap area, including ailerons | 285 sq ft |
| (3) Aileron area, total | 91 sq ft |
| (4) Aileron area, aft of hinge line | 64 sq ft |
| (5) Horizontal tail area, total | 230 sq ft |

(c) Total aileron — 290 in

(d) Chord, aft of hinge line (average percent wing chord) — 17%

d. Flaps

(1) Semi-span (normal to plane of symmetry, fuselage side to inboard end of aileron) — 220 in

(2) Chord (average percent wing chord)

(a) Root — 34%

(b) Tip — 39%

e. Vertical Tail

| | |
|---|---|
| (1) Height | 18 ft |
| (2) Root chord | 178 in |
| (3) Tip chord | 106 in |
| (4) Mean aerodynamic chord | 143.5 in |
| (5) Thickness ratio | 12% |
| (6) Taper ratio | 1.75:1 |
| (7) Aspect ratio | 1.55:1 |
| (8) Airfoil | NACA 0012 (modified) |
| (9) Volume coefficient | 0.097 ft |
| (10) Vertical tail arm (from aerodynamic center of wing to aerodynamic center of vertical tail) | 39.8 ft |

f. Horizontal Tail

(1) Span — 36 ft

| | | |
|---|---|---|
| (6) | Elevator area, aft of hinge line | 86 sq ft |
| (7) | Vertical tail area, total | 211 sq ft |
| (8) | Rudder area, aft of hinge line | 84 sq ft |

c. Wings

| | | |
|---|---|---|
| (1) | Root chord | 142 in |
| (2) | Transport joint chord | 142 in |
| (3) | Tip chord | 67.8 in |
| (4) | Mean aerodynamic chord | 120.9 in |
| (5) | Aspect ratio | 9:9:1 |
| (6) | Taper ratio | 2.1:1 |
| (7) | Airfoil section designation | |
| | Section from root to transport joint | 643A 417.5 |
| (8) | Incidence | |
| | (a) At root and transport joint | 3 deg |
| | (b) At tip | 0 deg |
| (9) | Anhedral, root to transport joint | 7 deg |
| (10) | Dihedral, transport joint to tip in chord plane | 2 deg |
| (11) | Sweepback along leading edge | 9 deg |
| (12) | Ailerons | |
| | Span (normal to airplane center line) | |
| | (a) Inner aileron | 117 in |
| | (b) Outer aileron | 173 in |

(2) Chord

(a) At root — 88 in

(b) At tip — 66 in

(c) Mean aerodynamic — 77 in

(d) Airfoil — NACA 63A series (modified)

(e) Aspect ratio — 5.64:1

(f) Dihedral — 0

## 2.0 FLIGHT LIMITS

### 2.1 CENTER-OF-GRAVITY LIMITS

| Forward % MAC | Aft % MAC | Gross Weight lb |
|---|---|---|
| 31.0 (STA 347.5) | 39 (STA 357.0) | 31,300 |
| 31.0 (STA 347.5) | 39 (STA 357.0) | 28,500 |
| 29.3 (STA 345.4) | 39 (STA 357.0) | 26,000 |
| 26.0 (STA 341.4) | 39 (STA 357.0) | 21,000 |

These limits are for the landing gear extended. The C.G. moves .6 percent MAC forward during landing gear retraction.

### 2.2 GROSS WEIGHT LIMITS

(a) Design gross weight — 26,000 lb

(b) Maximum gross weight — 28,500 lb

(c) Ferry takeoff gross weight — 31,300 lb

### 2.3 AIRSPEED LIMITS AT 28,500 POUNDS

(a) Never exceed — 208 KIAS

(b) Cruise (normal) — 165 KIAS

(c) Flaps fully extended (40 deg power on) — 80 KIAS

(d) Flaps fully extended (40 deg power off) 80 KIAS

(e) Gear Extended 120 KIAS

2.4 LIMIT FLIGHT LOAD FACTORS

(a) Design gross weight 26,000 lb

(b) Maneuver:

(1) Positive 2.90

(2) Negative -1.50

(c) Maximum gross weight 28,500 lb

(d) Maneuver:

(1) Positive 2.60

(2) Negative -1.40

(e) Ferry gross weight

(f) Maneuver:

(1) Positive 2.4

(2) Negative -1.25

3.0 ENGINE RATINGS AT SEA LEVEL

| Rating | Revolutions per Minute | Shaft Horsepower | Mixture | Time |
|---|---|---|---|---|
| Takeoff (TO) | 2700 | 1450/Eng | Rich | 5 min |
| Maximum continuous power (MCP) | 2550 | 1220/Eng | Rich | 30 min |
| Normal rated power (NRP) | 2250 | 1050/Eng | Rich | Cont. |
| Power for level flight (PLF) | 2200 | 725/Eng | Lean | Cont. |
| Power-off (PO) | 700-1200 | - | Rich | - |

## 4.0 CONFIGURATION

| Configuration | Flaps | Gear | Power |
|---|---|---|---|
| Cruise (CR) | Up | Up | PLF |
| Power-on (Level Flight) | Up | Up | NRP |
| Glide (G) | Up | Up | PO |
| Power-on (Climb) | Up | Up | NRP or MCP |
| Takeoff (TO) (STOL) | 30° for gross weights up to 26,000 lb. 25° for higher gross weights | Down | TO |
| Landings (L) (STOL) | 40° | Down | (Idle) |

## 5.0 WEIGHT AND BALANCE

The test airplane was weighed prior to initial flight. The test basic weight, including test airplane, test instrumentation, full oil, and trapped fuel, was 20,066 pounds. A change in the C.G. was accomplished by moving the ballast to various positions in the main cabin.

The following loading schedules were used:

a. Light Weight

| Item | Weight |
|---|---|
| Basic weight | 20,066 lb |
| Crew of 3 with parachutes | 580 |
| Fuel (166.5 @ 60 lb/gal) | 1,000 |
| Ballast located as required to obtain a C.G. of 32.9% of MAC (Mid) | 354 |
| | 22,000 lb |

b. Medium Weight

| Item | Weight |
|---|---|
| Basic weight | 20,066 lb |
| Crew of 3 with parachutes | 580 |
| Fuel (509 gal @ 6 lb/gal) | 3,054 |
| Ballast located as required to obtain C.G.'s of 29.3% of MAC (Fwd), 34.2% of MAC (Mid) and 39% of MAC (Aft) | 2,300 |
| | 26,000 lb |

c. Medium-Heavy Gross Weight

| Item | Weight |
|---|---|
| Basic weight | 20,066 lb |
| Crew of 3 with parachutes | 580 |
| Fuel (800 gal @ 6 lb/gal) | 4,800 |
| Ballast located as required to obtain a C.G. of 34.5% of MAC (Mid) | 1,554 |
| | 27,000 lb |

d. Maximum Gross Weight

| Item | Weight |
|---|---|
| Basic weight | 20,066 lb |
| Crew of 3 with parachutes | 580 |
| Fuel (800 gal @ 6 lb/gal) | 4,800 |
| Ballast located as required to obtain C.G.'s of 31.0% of MAC (Fwd), 35.0% of MAC (Mid) and 39.0% of MAC (Aft) | 3,054 |
| | 28,500 lb |

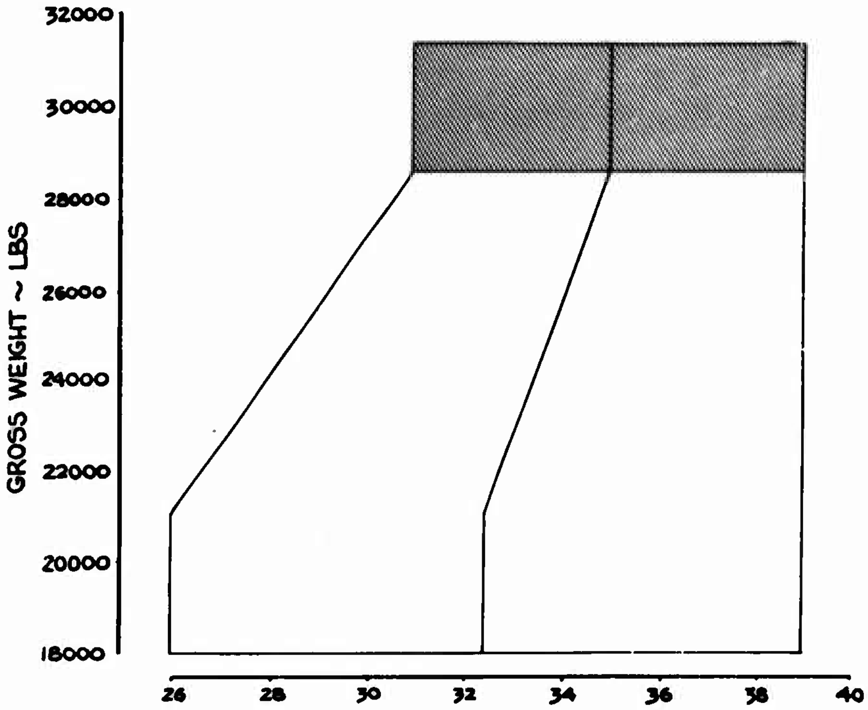
e. Ferry Gross Weight

| Item | Weight |
|---|---|
| Basic weight | 20,066 lb |
| Crew of 3 with parachutes | 580 |
| Fuel (800 gal @ 6 lb/gal) | 4,800 |
| Ballast located as required to obtain a C.G. of 35.0% of MAC (Mid) | 5,854 |
| | 31,300 lb |

The C.G. envelope for CV-2B can be found in Figure A.

FIGURE A

GROSS WEIGHT VS CV-2B AIRPLANE CENTER OF GRAVITY



## 6.0 FLIGHT CONTROL SYSTEM

The flight control system employed in the CV-2B is reversible about all three axes and is characterized by simplicity of design consistent with the requirement for acceptable airplane handling qualities. The entire primary control system is mechanically actuated by cables, push-pull rods, bell cranks and pulleys except for the lateral trim system which is electrically actuated.

### 6.1 LONGITUDINAL CONTROL SYSTEM

Longitudinal control is obtained by means of a stabilizer/elevator actuated by fore and aft movement of the dual, interconnected control columns. Longitudinal trim change due to flap actuation is automatically compensated for by a corresponding incidence change in the horizontal stabilizer which is mechanically linked to the flaps. Spring tabs, located on the elevators, are used to obtain aerodynamic boost and a more favorable stick-free stability gradient. Trim tabs, also located on the elevators, are mechanically actuated by a hand wheel in the cockpit and are used to obtain longitudinal trim.

### 6.2 LATERAL CONTROL SYSTEM

Lateral control is obtained by means of ailerons, mechanically actuated by dual, interconnected control wheels mounted on the control columns. The ailerons, consisting of an inboard and outboard section on each wing, are also linked to the flap system so that as flaps are lowered both inboard and outboard ailerons "droop" to provide additional flap surface for STOL operations.

Aileron maximum deflections with the flaps lowered are increased over the maximum deflections available with the flaps fully retracted. This is to provide increased lateral control power in the STOL speed range. A tab, mounted on the right inboard aileron, is mechanically linked to the rudder and is actuated by rudder movement to improve the dihedral effect characteristics of the airplane. Two geared servo tabs, one on each outboard aileron, are employed to reduce lateral force gradients. One trim tab, mounted on the right-hand outboard aileron and electrically actuated by a switch on each control wheel, is used to trim the airplane laterally.

## 6.3 DIRECTIONAL CONTROL SYSTEM

Directional control is obtained by means of a vertical stabilizer/rudder mechanically actuated by dual interconnected rudder pedals. A geared trim tab is incorporated at the tailing edge of the rudder. The tab is mechanically actuated by a hand wheel in the cockpit. In addition to acting as a trim device, this tab acts as a geared servo tab to reduce directional force gradients. A spring tab, fitted to the trailing edge of the rudder, is also used to improve directional force gradients.

## 6.4 STALL WARNING SYSTEM

A two-stage artificial stall warning system, consisting of wing-mounted lift transducers, flap potentiometers, lift computers and electrically activated stick shakers, is incorporated in the airplane. The transducers are activated by vanes, located in the leading edge of each wing, which are sensitive to the movement of the aerodynamic stagnation point. After modification of the transducer signal for flap position and gross weight, an electrical signal relayed to the stick shaker mechanism activates the shakers. The low-intensity shaker is activated at approximately 8 - 10 knots above the stalling speed and produces a low-amplitude, high-frequency vibration in the control column. The high-intensity stick shaker, activated at approximately 4 - 5 knots above the stalling speed, produces a high-amplitude low-frequency vibration. The high-intensity stage operates only when flap setting is 19 degrees or more and when the throttles are more than 3/4 inch forward from the fully closed position.

## 6.5 SAFE FLIGHT INDICATOR

The test airplane had a Safe Flight Indicator installed on top of the left main instrument panel. This indicator consisted of a needle and three index marks corresponding to 23,000, 26,000 and 28,500 pounds gross weight. The system was activated by one of the stall warning transducer vanes in the wing leading edge to present continuous angle-of-attack information for STOL approaches at the gross weights stated above.

## 7.0 TEST INSTRUMENTATION

The test instrumentation used during this test program was supplied, calibrated, installed and maintained by the Instrumentation Branch of USAAVNTA. A swivel-type pitot-static airspeed head was installed on a nose boom which extended 4 feet forward from the nose of the airplane. The following parameters were measured by sensitive instrumentation:

a. Cockpit Instrument Panel:

Sensitive Airspeed Indicator (Boom System)

Sensitive Airspeed Indicator (Airplane's Standard System)

Altitude (Boom System)

b. Photo Panel:

Sensitive Airspeed Indicator (Boom System)

Sensitive Airspeed Indicator (Airplane's Standard System)

Altitude (Boom System)

Clock (Time of Day)

Stop Watch

Free Air Temperature

Manifold Absolute Pressure (Right and Left Engines)

Carburetor Air Temperature (Right and Left Engines)

c. Oscillograph:

Linear Acceleration (Longitudinal)

Linear Acceleration (Vertical)

Five Structural Load Channels:

(1) Nose Gear Drag Strut

(2) Right Main Gear Drag Strut

(3) Left Main Gear Drag Strut

(4) Right Main Gear Short Strut

(5) Left Main Gear Short Strut

Engine Tachometer (Right and Left Engines)

Stepper Motor Fuel Timer (Right and Left Engines)

Fuel Used* (Right and Left Engines)

Correlation Counter for Oscillograph

*Total fuel used was measured by a potter flow meter system which activated totalizing counters and stepper motor fuel times on the Photo Panel.

# Appendix IV
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| 1. ORIGINATING ACTIVITY *(Corporate author)*<br>U. S. Army Aviation Test Activity (USAAVNTA)<br>Edwards Air Force Base, California | 2a. REPORT SECURITY CLASSIFICATION<br>UNCLASSIFIED<br>2b. GROUP |

3. REPORT TITLE

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4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Final Report, 25 August 1963 through 20 January 1964

5. AUTHOR(S) *(Last name, first name, initial)*

Finnestead, Rodger L., Project Engineer, and
Antoniou, Michael N., Captain, U. S. Army, TC, Project Pilot

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
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| c.<br>USAAVNTA Project No. 63-74<br>d. | 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*<br>N/A |

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|---|---|
| | U. S. Army Materiel Command<br>Washington, D.C. |

13. ABSTRACT


Engineering flight tests were conducted to evaluate the performance and flying qualities of the CV-2B airplane, with special emphasis on takeoff and landing performance in the short takeoff and landing (STOL) configuration. Tests were conducted at test sites in Bakersfield, Edwards, Bishop, Eldorado County Airport, and Coyote Flats, California. The program consisted of 120 hours of flight testing and was accomplished during the period 25 August 1963 through 20 January 1964. An interim report was submitted to the Assistant Chief of Staff for Force Development, U. S. Army, 9 March 1964.

The test airplane (U.S. Army S/N 62-4175) was modified from a CV-2 to a CV-2B by the incorporation of the following major changes:

a. STOL operation capabilities were increased from 26,000 to 28,500 pounds.

b. Reverse pitch propellers were installed.

The STOL performance data obtained during this test revealed that the Operator's Manual (TM-55-1510-206-10) does not adequately present STOL procedures for all combinations of gross weight, altitude and C.G. positions.

The cruise performance data were compared with those in the Operator's Manual. This comparison revealed that no significant differences existed. The Operator's Manual, however, does not present any level flight data for the ferry gross weight of 31,300 pounds.

The stall characteristics information presented in the Operator's Manual for the STOL configuration is inadequate.


DD FORM 1 JAN 64 1473

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| 14. KEY WORDS | LINK A | | LINK B | | LINK C | |
|---|---|---|---|---|---|---|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| CV-2B Airplane | | | | | | |
| STOL Airplane | | | | | | |
| Caribou | | | | | | |
| Performance Tests | | | | | | |
| Flying Qualities | | | | | | |
| Medium Troop/Cargo Transport | | | | | | |

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